

**MODELS FOR PREDICTING THE COMPRESSIVE
STRENGTH OF COMPRESSED STABILIZED
EARTH BLOCKS**

BY

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CERTIFICATION

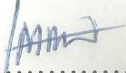
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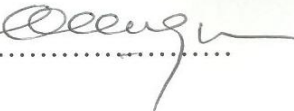
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DEDICATION

This work is dedicated to my mother, Mrs. Elizabeth Iwu

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ABBREVIATIONS

CSEBs = Compressed stabilized earth blocks

MPa = Mega Paschal

ILO = International Labour Organisation

OPC = Ordinary Portland Cement

GOF = Goodness of Fit

W/C = Water cement ratio

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ABSTRACT

This study presents models for predicting the compressive strength of compressed stabilized earth blocks (CSEBs). The blocks were produced using Ordinary Portland Cement (OPC) and suitable soil obtained by mixing laterite, river sand, and granite chippings in appropriate proportions. Varying OPC contents of 5%, 6% and 8% were used. A constant compressive pressure of 6MPa was used in molding all the blocks using universal compression machine. 27 mix ratios were used for the work, 18 for designing the models, and 9 for testing them. Three blocks were molded for each mix ratio, compressed, and cured by sprinkling of water twice daily and covering with nylon mat for 28 days, after which the blocks were crushed at saturated surface dry state. Using Ibearugbulem's Regression Function, three mathematical models were formulated for predicting the compressive strengths of CSEBs when the mixture proportions are known. The average 28th day compressive strength values of the blocks for 5%, 6%, and 8% OPC content were 3.6N/mm², 5.5N/mm² and 6.8N/mm² respectively, well above the 2.5N/mm² recommended by The Nigeria Industrial Standard (NIS 87: 2000) for load bearing walls. The compressive strength values predicted by model 2 at 5%, 6%, and 8% OPC content were 3.50N/mm², 5.53N/mm² and 7.30N/mm² respectively, while the corresponding laboratory values were 3.60N/mm², 5.50N/mm² and 7.31N/mm² respectively. Predicted and laboratory values for models 1 and 3 were similarly close. The predictions from the three models were tested with the statistical Fisher test and found to be adequate at 95% confidence level. Thus, the models are suitable for predicting the compressive strength of CSEBs compressed with a pressure of 6MPa.

Keywords: Response function, Earth blocks, Compressive strength, Stabilization

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF STUDY

Brick, cement, sand and timber are the major construction materials used within Africa presently. However for the majority of people in Africa, and especially in Nigeria, these construction materials are unaffordable, therefore a construction technique that can provide sturdy buildings at low cost is required. The new technique in vogue comes in the form of earth as a construction material and progressively earth blocks (Anifowose, 2000). Around 30% of the world's population and roughly 50% of the population of developing countries live in earthen structures (Easton, 1998). However, many of these earthen structures are inadequate with little structural integrity or durability, most of them are unsuitable for homes of more than two stories, as they are unable to carry the load of the upper walls (Udoeyo et al, 2006). The lower walls would need to be thicker than the upper walls in the same building, resulting in increased labour costs, thus causing more problems for their owners. Therefore in addition to formulation of models that can predict the compressive strength of CSEBs, this study seeks to produce affordable earth blocks of high strength that can be used as load bearing walls.

In this chapter, attempts have been made to outline the motivation and objectives for the research work, and explain the need for the research.

1.2 Statement of problem

The majority of developing countries are today faced with an ever increasing problem of providing adequate and affordable housing in sufficient numbers. In the last few decades, housing demand has risen; hence the need for sturdy low cost buildings to house people. Lack of knowledge in this area justifies the need for more research to be focused on compressed stabilized earth blocks.

1.3 Objectives of study

The main objective of this study is to develop models for predicting the compressive strength of compressed stabilized earth blocks (CSEBs).

The specific objectives are:

- (i) To produce CSEBs compressed with a pressure of 6Mpa;
- (ii) To determine the compressive strength of CSEBs compressed with a pressure of 6MPa for various mix proportions;
- (iii) To develop models for predicting the compressive strength of CSEBs compressed with a pressure of 6Mpa;
- (iv) To produce earth blocks that meets the strength requirement for load bearing walls;
- (v) To determine the effects of clay and cement contents on the compressive strength of CSEBs.

1.4 Scope of study

In this study, the performance of the blocks was based only on the 28th day compressive strength, among many other properties of compressed stabilized earth blocks. This research considered only the use of ordinary Portland cement as the binder, and soil from Obinze in Imo State.

In this study the following will be covered: extensive review of related literature; sourcing and selection of materials and evaluation of relevant materials characteristics; experimental tests to determine the liquid limit, plastic limit, plasticity index, particle size distribution, optimum moisture content and maximum dry density of the laterite; analysis of experimental results and formulation of mathematical models; statistical analysis of both experimental and model results.

1.5 Justification of study

This study has a lot of merits especially the application of a locally available, cheap and easy to use natural resource in block production.

The presentation of mathematical models that can be easily used to predict the desired strength of CSEBs and the prescription of soil compositions that can be used to produce earth blocks that meet the strength requirement for load bearing walls will be very useful to block manufactures, civil engineers and architects.

CHAPTER TWO

LITERATURE REVIEW

2.1 History of Earth Construction

Earthen building techniques are not new concepts and their application has been known for over 9,000 years (Keefe, 2005). Earthen structures throughout history are evident around the world. Several traditional options include: rammed earth, fired clay/mud, earthen blocks, adobe, etc. Structures including the Great Wall of China, the Temple of Ramses in Egypt, the Sun Pyramid in Mexico and the mosque of Timbuktu in Mali which are still standing today are all founded on earthen building technology (Minke, 2006).

The history of earth buildings lacks documentation because it has often been considered inferior compared to that of stone and wood (Houben and Guillaud, 1994). As stated by Easton (1998) “30% of the world’s population, or nearly 1,500,000,000 people, live in a home built in unbaked earth. Roughly 50% of the population of developing countries, the majority of rural populations, and at least 20% of urban and suburban populations live in earth homes”.

Modern earth buildings take many forms around the world. In the UK, the placing of damp clay soil to form walls known as “cob” is particularly wide spread in Devon and Hampshire (Ben and John, 2000). Moist soil placed between removable formwork boards is called “rammed earth” and is found

around the Mediterranean rim, north India and western China (Jaquin, 2008). In Germany, clay plasters are becoming increasingly popular as they are felt to improve the internal ambience of buildings (Minke, 2006). In Uganda, Sudan and other African countries earth blocks have successfully been used (Zami and Lee, 2009).

2.2 COMPRESSED STABILIZED EARTH BLOCKS VERSUS OTHER BUILDING MATERIALS

Compressed earth blocks represent a considerable improvement over traditional earth building techniques. When guaranteed by quality control, compressed earth block products can very easily bear comparison with other materials such as the sand-cement block or the fired brick as shown on Table

2.1

Table 2.1: Properties of compressed stabilized earth blocks versus other walling materials

Property	Compressed stabilised earth blocks	Fired clay bricks	Calcium silicate bricks	Dense concrete blocks	Aerated concrete blocks	Light weight blocks
Wet compressive Strength (MPa)	1 – 40	5 – 60	10-55	7-50	2-6	2-20
Moisture movement (%)	0.02 – 0.2	0.0-0.02	0.01-0.035	0.02-0.5	0.05-0.10	0.04-0.08
Density (Kg/m ³)	1700– 2200	1400-2400	1600-2100	1700-2200	400-950	600-1600
Thermal conductivity w/m°C	0.81 – 1.04	0.70-1.30	0.10-1.60	1.0-1.7	0.10-0.20	0.15-0.70
Durability against rain	Good to very poor	Excellent to very poor	Good to moderate	Good to poor	Good to moderate	Good to poor

Source: Adam and Agib (2001)

2.2.1 Compressive strength

The compressive strength of compressed stabilized earth blocks (i.e. the amount of pressure they can resist without collapsing) depends upon the soil type, amount of stabilizer, and the compaction pressure used to form the block (Lasisi and Ogunjimi,1984). Maximum strengths are obtained by proper mixing of suitable materials and proper compacting and curing (Morel and Pkla, 2002).

Several different minimum values of 28th day wet compressive strength, all above 1.0 MPa are proposed; some of the recommendations by different authors for the minimum compressive strength of compressed stabilized earth block ranges from 1N/mm² to 2N/mm² (Adam and Agib, 2001).

In practice, typical wet compressive strengths for compressed stabilized earth building blocks may be less than 4MPa. It is strength suitable for many building purposes (Guettala et al, 2006) . It also competes favorably, for example, with the minimum British Standard requirements of 2.8MPa for precast concrete masonry units and load bearing fired clay blocks, and of 5.2MPa for bricks (Adam and Agib, 2001).

2.2.2 Density and thermal properties

Normally compressed stabilized earth blocks are denser than a number of concrete masonry products such as aerated and lightweight concrete blocks however its densities are within the range of various types of bricks e.g. clay, calcium silicate and concrete bricks (see Table 2.1). The high density of compressed stabilized earth blocks may be considered as a disadvantage when

the blocks have to be transported over long distances; however, it is of little consequence when they are produced at or near the construction site. Low density compressed stabilized earth blocks have an advantage over high density ones for acting as better thermal insulators. This is particularly advantageous in hot dry climates where extreme temperatures can be moderated inside buildings made of compressed stabilized earth blocks (Minke, 2006).

2.2.3 Moisture movement

Building materials with high porosity when used for wall construction may expand slightly in wet and dry conditions. Such movements may result in cracking and other defects to the building (Oti and Kinuthia 2009). Expansion of compressed stabilized earth blocks may vary according to the properties of the soil; some soils expand or shrink more than others (Adam and Agib, 2001). The addition of a stabilizer will reduce this expansion (ILO and UNIDO, 1984). In general, however, there may be greater movement in structures built with compressed stabilized earth blocks than those using alternative construction materials (Walker, 1999). Proper block manufacture and construction methods, however, will reduce such movement (Reddy and Kumar, 2010).

Moisture movement is denoted in terms of linear percentage. It is worth mentioning that moisture movement becomes especially important when two materials with different movement properties are used in a building (Walker, 2004). Differential movement results in stress, which may break the bond between the materials, or cause other damages. For example, cement renderings

often peel off earth walls of poorly compressed stabilized earth blocks because of their different expansion properties (Adam and Agib, 2001).

2.2.4 Durability, Maintenance and Appearance

Soil blocks containing stabilizers show greater resistance to extreme weather conditions (Heartcote, 1995). Blocks of the same size, when made of a sufficiently good quality and shape with a high quality finish, can be used for fair-faced walling. Their appearance depend on soil colours, particle size, and degree of compaction used (Jaquin, 2008). With high quality blocks external or even internal rendering should not be necessary. A white wash finish applied directly to the blocks as a render coat could be used to reduce solar gain. It should be noted that compressed stabilized earth blocks, in common with other types of blocks and bricks, would need adequate steel reinforcement if used in areas prone to earthquakes or cyclones (Walker and Stace, 1997). Termites, bacteria, fungi and fire do not present a particular hazard for compressed stabilized earth blocks (Adam and Agib, 2001). However, organic material in the soil may weaken the strength of the block.

2.3 THE MAIN CONSTITUENT MATERIALS USED IN THE PRODUCTION OF CSEBs

According to (Gooding and Thomas, 1995) the three main constituent materials used in the production of CSEBs are:

- Ordinary Portland Cement (for binding the soil particles)
- Soil (for the skeletal structure of the block)

- Water (for the hydration of cement and lubrication of soil particles)

These three materials each have unique properties. Before discussing how they are combined to form blocks, a description of their nature and properties is presented.

2.3.1 Ordinary Portland Cement as the main binder

Ordinary Portland cement is an important ingredient and variable in CSEBs. Without its inclusion, compressed earth blocks would be no different from common sun dried mud blocks and would simply disintegrate in contact with water, or when subjected to moderate impact loads (Bell, 1996). Compared with concrete products where 12-18% by weight of cement is used, only about half of that amount (5-8% by weight), is required in stabilized blocks (Houben and Guillaud, 1994). Though not commonly recommended, amounts as low as 3% and as high as 10%, have been used depending on the nature of the soil requiring stabilization (Rigassi, 1995).

The function of OPC is to strongly bind the constituent materials (soil particles) together, in a dense, strong, dimensionally stable and durable unit. Other common binders currently in use include lime, gypsum, pozzolans, resins and bitumen.

Discussions in this thesis will be restricted to the use of OPC. The uniqueness of OPC in comparison with other binders is based on its ability to achieve high strengths in only a short period of time (about 28 days). OPC stabilized blocks

remain dimensionally stable even when in contact with water in a manner not possible for stabilized blocks produced in a similar way. Uncontrolled swelling and shrinkage are appreciably contained when OPC is used (Rigassi, 1995).

For stabilized blocks, variations in OPC quality and amount can drastically affect its properties and behaviour more than any other input variable (Gooding, 1993).

Unfortunately the manner of current coverage of OPC in CSEBs literature leaves a lot to be desired. The coverage is so limited, scanty and routine that widespread and incorrect use of the binder is now becoming the order of the day (Fullerton, 1979).

2.3.2 Characterisation of soil for CSEBs production

According to BS 1377 Part 1: 1990, soil is an assemblage of discrete particles in the form of a deposit, usually of mineral composition, but sometimes of organic origin, which can be separated by gentle mechanical means, and which include variable amounts of water and air. Soil is also referred to as the loose material that results from the long-term transformation of the underlying parent rock by the simultaneous and evolutionary interaction of climatic factors and other physico-chemical and biological processes (Houben and Guillaud, 1994).

Most of soils consist of disintegrated rocks, decomposed organic matter and water soluble mineral salts. These descriptions confirm that soil is a highly variable and complex material in nature. Although soil properties can be

modified to improve their performance, not all soils may be suitable for stabilization as found. The decision on suitability requires the identification of the main constituents in the soil likely to have a direct bearing on its properties and behaviour (Head, 1980).

As the characteristics of a soil can affect the performance of CSEBs, the review of literature discussed in this section will focus on the following:

- Composition of soils
- Classification of soil (to determine type and suitability)
- Current criteria for selection of suitable soils

2.3.2.1 Soil composition

Soil consists of three main phases, namely, solids, liquids and gasses (Arora, 1997). The solids form the bulk of the material, while the liquids and gasses mainly fill the void spaces. The relative proportions of the three phases can have a significant influence on the behaviour of a soil. In this section only the composition of the solids fraction are discussed. Soils are made of varying proportions of four types of solids: gravel, sand, silt and clay (Scot, 1963).

Each of these different solids are briefly discussed in turn in the ensuing paragraphs.

Gravels are the larger granular particle sizes in a soil forming its skeletal structure. They range in size between 2mm and 20mm (BS 1377 Part 2: 1990).

They are the cohesionless part of a soil resulting from the direct disintegration

of underlying parent rocks and pebbles (Pettijohn, 1957). Gravels have a rough texture and may be found in almost all shapes, including rounded, angular, irregular, etc. (BS 1377 Part 2: 1990). Due to their loose packing and stability, they are important for CSEBs production as they limit shrinkage and capillarity in a soil. Amounts of gravel in excess of 10% are not recommended for use in CSEBs production (Rigassi, 1995). The allowable maximum size fraction for gravel used for CSEB production is not standardised. Some literature sources recommend 15mm to 20mm (Houben and Guillaud, 1994), while others recommend 6mm (ILO and UNIDO, 1984).

Sand particles in a soil range in size between about 0.06mm and 2mm (BS 1377 Part 2: 1990). The sandy fraction comprises granular grains of silica or quartz from the disintegration of sandstones and crystalline rocks. Sandy soils are very stable, lack cohesion, and are non-sticky with a gritty texture. They also have a very high degree of internal friction and do not shrink. Because of these properties, they provide the much needed mechanical strength to soil. According to literature sources, the specific bulk density of sands vary between 2500 kg/m^3 and 3000 kg/m^3 , but their specific surface area is about $23 \text{ cm}^2/\text{g}$, and specific heat about 800 J/kgK (Jones, 1984). The recommended proportion of sand in soils for CSEBs production varies but is mainly between 70 and 80% (Lunt, 1980; Rigassi, 1995).

Silts are made up of particles whose size range varies between 0.002mm and

0.06mm (BS 1377 Part 2: 1990). Apart from the difference in size, silts are almost identical in nature to sandy particles. Their internal friction is however noticeably less than that of sand. Their specific surface area is about $454 \text{ cm}^2/\text{g}$ and density between $1600 \text{ kg}/\text{m}^3$ and $1800 \text{ kg}/\text{m}^3$ (Head, 1980; Houben and Guillaud, 1994). They have a smooth texture, are sticky and lightly cohesive, but their shrinkage capacity is not significant. Due to their lack of cohesion, gravels, sands and silts should not be used on their own for CSEBs production. The recommended silt fraction in a soil for CSEB production should be between 10% and 25% (Rigassi, 1995).

Clay particles form the finest fraction of soils with average sizes less than $2 \mu\text{m}$ (Scot, 1963). Their physical and chemical characteristics are not similar to those of the other three soil fractions. The specific surface area of clay is about $800 \text{ m}^2/\text{g}$, while its specific heat is about $965 \text{ J}/\text{kgK}$ (Houben and Guillaud, 1994). Due to their fine grained nature, clays are cohesive and will form a coherent mass at suitable moisture contents (Vickers, 1983; BS 1377 Part 1: 1990). They are basically hydrated alumino-silicates of irregular but often hexagonal shapes (Torraca, 1988). The presence of clay in moderate amounts in a soil is desirable (Smith and Smith, 1998). Being cohesive, they impart plasticity to the soil when under moist conditions. Plasticity is due to the thin film of absorbed water which adheres strongly to the clay layers thus linking the particles together (Grimshaw, 1971). In this way, the clay minerals act as natural binding agents

for the cohesionless granular fractions of a soil (gravel, sand, and silt). This quality is particularly valuable during the production of CSEBs. Green blocks after demoulding are still weak as the cement binder may not yet have had sufficient time to set. The presence of clay as a natural binder thus helps in the handleability of CSEBs at this stage of the production process (Spence and Cook, 1983).

Clay minerals also have other properties which are unfortunately considered undesirable in a block. Being hydrophilic they have a very high affinity for water (Rahman, 1987). As the wafers attract water, clay particles can slide over each other resulting in an apparent increase in volume. Conversely, as the clay wafer dry out, they shrink, causing cracks to appear in the clay mass, thus effectively irreversibly breaking their bond strength (Hilt and Davidson, 1960). Extreme swelling and shrinkage are not desirable properties in blocks (Pacheco-Torgal and Jalali, 2012). It is the uncontrollable swelling and shrinkage of clays which depend on moisture and temperature variations that make them unique, and thus difficult to deal with. For this reason, most CSEB literature sources recommend controlling the amount of clay in soils to be used for block production. An amount of clay in excess of 40% is not recommended for soils for CSEB production using OPC (Rigassi, 1995). In such cases, the use of lime as stabilizer is recommended due to its ability to fix the clay through a pozzolanic reaction (Spence and Cook, 1983).

2.4 SOIL CLASSIFICATION

Soils are classified in various ways depending on the prevailing local or regional standards in the particular part of the world. Whatever the geographic location, however, some common procedures are usually adopted in the classification of soils. Soil classification methods are based on either one or a combination of the following: particle size distribution, plasticity, cohesion, and organic matter content (Arora, 1997). Unfortunately, soil classification systems are not yet uniformly applied internationally. At the moment, the two classification systems widely used are based on the particle size distribution and on the plasticity of a soil (Lunt, 1980). According to these two methods, the soil size grading and its plasticity are divided into clearly defined ranges. For each range, a descriptive name and letter is assigned to the identified soil type to distinguish it from others. In the particle size distribution classification system, the term particle refers to an individual mineral grain within the disturbed soil mass. According to this system, the following size ranges are given as shown on Table 2.2.

Table 2.2: Soil classification according to particle size distribution

Name	Particle Size (mm)		
	Coarse	Medium	Fine
Gravel	60 - 20	20 - 6	6 to 2
Sand	2 – 0.6	0.6 – 0.2	0.2 – 0.06
Silt	0.06 – 0.02	0.02 – 0.006	0.006 – 0.002
Clay			< 0.002

Source: BS 1377: Part 2 (1990)

In this system, each of the terms gravel, sand, silt and clay refers to a range of particles or grain sizes in a soil (Table 2.2). In actual reality, soils are not found in this rigidly defined state. The normal natural state of soil is such that it is composed of grains from two or more particle size ranges. For example, a soil may be described as Sandy CLAY, implying that the soil has significant amounts of sand and clay size ranges. In such a case, the size range with the higher percentage of particles is the last named range in the soil description (in capitals). The main terms used in this system are G for GRAVEL (60-2mm), and S for SAND (2-0.06mm). The qualifying terms are W for well graded and P for poorly graded (Pu, uniform; Pg, gap graded).

In the soil plasticity classification system, the soil is identified by its behaviour when in contact with water. The system is mostly used for the finer fraction of

a soil, i.e. clays and silts smaller than the 425 μ m sieve only (Houben and Guillaud, 1994). The soil is then classified using a soil plasticity chart (Das, 1994). Use of both the particle size and plasticity based classification systems are recommended in analysing soils for CSEB suitability. The identification of a particular soil can be considered complete with the inclusion of its colour, particle shape and composition, soil name based on its grading and plasticity, and the soil group symbol. The approach is useful in that it clearly recognises the difference between the coarse and fine soil fractions (Arora, 1997).

2.5 SUITABLE SOIL FOR CSEB PRODUCTION

A suitable soil should not contain organic material or excessive soluble salts, (Houben and Guillaud, 1994). These substances can interfere with the proper setting of OPC, thus weakening the hardened cement paste (Neville, 1995).

Its sand fraction should be well graded to provide a densely packed load-bearing skeleton for the block and its largest size particle should be small enough to give a smooth surface finish.

The fine fraction should be just sufficient to provide enough cohesion to the fresh block to prevent damage on ejection and transportation from the mould (ILO and UNIDO, 1984). Too large fines content will require large cement content for adequate stabilization. The cohesion of the fresh block will depend on the compaction pressure used and the type as well as the quantity of clay present in the fines (Balogun and Adepegba, 1982).

The summary of existing criteria for soil selection is shown on Table 2.3. It is not an exhaustive review but rather included as an indication of the variation between authors and as a warning that such criteria should be used as a guide in initial soil selection rather than as a rigid set of rules.

It is however noted that some of the suggested criteria, while based on similar properties, still differ from each other. Such dissimilarities only confirm the premise that the variability of soil makes selecting a suitable soil a difficult exercise. Nevertheless, although the effect of climatic type and infinite variability of soils may influence some of the existing guidelines, most of the criteria still appear relevant to date. It is however, still rare to find authors recommending 'comprehensive' criteria based on all the four main soil properties, namely: particle size distribution, plasticity, compressibility, and chemical mineralogy.

Table 2.3: Summary of existing criteria for soil suitability

S/N	AUTHOR	YEAR	BASIS OF CRITERIA	DETAILS
1	Fitzmaurice	1958	Particle size distribution Plasticity	Range: Sand 33-40% (min.) Clay 20-30% (max.) not < 5% Stabilizer: OPC: 5-10% Liquid limit: 40 - 50% Plasticity index: 2.5 - 22%
2	Houben and Guillaud	1994	Particle size distribution Plasticity	Range: Clay 5-20% Silt 5-40% Sand 40-90% Plasticity index 3-30% Liquid limit 24-37%
3	Rigassi	1995	Particle size distribution Plasticity	Range: Gravel 0 – 40 Sand 25 – 80% Silt 10 – 25% Clay 8 – 30% Stabilizer: OPC: 4 – 8% Plasticity index 15 – 20%
4	Houben et al	1996	Particle size distribution	Range: Gravel 0 – 40% Sand 25 – 80% Silt 10 – 25% Clay 8 – 30% Stabilizer: OPC: Optimum 5 - 6% Maximum 8% Minimum 2%

Source: Houben et al, (1996); Fitzmaurice (1958); Houben and Guillaud, (1994); Rigassi (1995)

The summary in Table 2.3 should not serve as rigid specifications for soil selection. This is because even soils that may fall out of the recommended ranges can, with modification, still be used to produce good blocks (Adam and Agib, 2001).

The validity of the various criteria is not investigated further in this thesis.

2.6 TESTS FOR SOILS

Prior to soil cement block production there are two main types of tests, which may be conducted: field tests and laboratory tests (Gooding, 1993).

2.6.1 Field tests

Field tests are for preliminary site surveying to identify if the soils are most likely suitable and so restrict the number of soils to be more rigorously assessed by laboratory tests (Rigassi, 1995). The tests will provide a rough idea of a soil grading and plasticity and also indicate whether a soil contains significant organic matter, a majority of gravel, a majority of sand or a majority of fines. They may also be able to distinguish whether silt or clay is a more significant fraction of the fines. They are generally fairly easy to perform and often require little or no experimental equipment, making them very simple to implement. Simple field tests which are performed to get an indication of the composition of the soil sample include: smell test, nibble test, touch test, sedimentation test and washing test (Gooding, 1993).

2.6.2 Laboratory tests

Laboratory tests can be used to characterize the soils by particle size distribution, plasticity or other numerical measures for relation to the selection criteria and enable simple soil modification by blending (Head, 1980). The tests establish numerical values for certain soil parameters, primarily the percentage distribution of the different sizes of soil particles present and the plasticity limits. These values are subsequently used to determine the best available soil.

There are four main types of laboratory tests: sieve analysis test, Atterberg limits test, sedimentation test, and compaction test (Adam and Agib, 2001).

The sieve analysis tests separate the different size fractions of the soil into discrete parts thereby indicating the soil particle grading. The silt and clay fractions are too small to be easily separated by sieving and as such are normally reported as a combined fraction (Arora, 1997).

The Atterberg limits test define the moisture content at which the soil passes from a liquid state to a plastic state and from a plastic state to a solid state; these boundary points are the liquid and plastic limits respectively (Jones, 1984).

The compaction test provides a relationship between the water content and the maximum dry density. The water content at which the maximum dry density is attained is obtained from the relationships provided by the test (Arora, 1997).

2.7 COMPRESSED STABILIZED EARTH BLOCK PRODUCTION PROCESS

The production process of CSEBs is broadly similar to that of sandcrete blocks. Similarities exist between the products, manufacturing process and in the organizational control methods. The processing method can significantly influence the quality and long term behaviour of the blocks (Rigassi, 1995).

CSEBs are produced by compressing a damp mix of soil and cement in a press mould. After demoulding, the green blocks are not used immediately, but are first allowed to cure. This is because the strength of a block, just as it is the case with sandcrete blocks, increases with age (Rigassi, 1995). The duration of curing is dictated by the specification for the type of stabilizer used; 28days when OPC is used and 56days when lime is used (Lea, 1970). The production of CSEBs can be organised as a small scale cottage concern or as a much larger mechanised industrial unit. Whatever the approach adopted, the production cycle is likely to remain similar, and can be categorized into four basic stages, namely:

- Soil extraction (and preparation)
- Mixing (soil, cement and water)
- Moulding (of the block)
- Curing (of the green blocks)

2.7.1 Soil extraction and preparation

Soil to be used for CSEB production should preferably be extracted from or near the proposed building site. Indeed this is one of the major attractions of using

CSEBs for building purposes. Sourcing the main raw material in this manner can significantly minimize expenses normally associated with transportation. Prior to extraction however, the soil at the potential site has to be properly identified and classified (Norton, 1997). It is only after this has been done, with the results being acceptable, that subsequent procedures including extraction may follow.

Identification of soil at the proposed extraction site may be facilitated if information on local soil types, or information based on experience can be obtained. Documented sources may include maps, previous construction records, etc. Even then, the soil will still need to be identified using field indicator tests followed by laboratory tests in that order (BS 1377 part 2, 1990). As stated earlier, the soil needed for CSEB production should contain some coarse fraction (fine gravel and sand), and some fines fraction (silt and clay). The clays in the fines fraction significantly contributes to binding the fine gravel, sand and silt together (Lunt,1980). If the soil is deemed satisfactory either for direct use as it is, or following blending with the missing soil fractions, then the extraction process can commence.

The soil is best extracted from the sub-soil level and not from the top-soil level (from about 300 mm downwards from the surface) (Adam and Agib, 2001). Disregarding of top-soil layers ensures that undesirable inclusion of organic matter, normally dominant at this level, is avoided. Another important

consideration before soil extraction can commence is whether the ground to be used as a pit can indeed supply enough soil for the particular size of the project. The pit should be located in an area large enough to generate and sustain the supply of sufficient raw material to satisfy the building requirements (Fitzmaurice, 1958). The process of soil extraction should only begin after it has been established that the soil is suitable, or can be modified to become suitable and that it is available in sufficient quantity (Gooding, 1993).

The soil may then be extracted either manually or by mechanical means. After the extraction of soil, further preparatory operations are still required.

Soil preparation after extraction involves drying out, pulverization, screening, Storing and stockpiling (Ashish et al, 2009). The just extracted soil can be dried out by spreading it out in thin layers on a hard level surface. By drying out the soil, an attempt is made to gradually free the soil particles from their entanglement and to obtain a material of almost even minimum moisture content (Zami and Lee, 2009). To achieve this fast enough, the thinly spread out soil should be regularly raked through in order to turn it over repeatedly. The drying operation can be verified as satisfactorily completed through visual examination of any changes in colour of both the top and bottom layers. When both the bottom and top layers of the spread out soil show a uniformly light colouration than when first obtained, then the soil can be considered to be dry enough. At this stage it should also be easy to break up any remaining

soil lumps by hand. These should mostly be clay lumps, since it is such fines that are responsible for forming nodules. Nodules of diameter greater than 10 mm should not be allowed (Houben and Guillaud, 1994). Simple hand tools such as wooden hammers, hoes, etc., can be used to pulverize and break up soil lumps. Pulverization and breaking up of lumps in this manner also helps speed up the drying process (by increasing the surface area). The pulverized soil can then be screened.

After screening, the soil can then be stockpiled awaiting use. From this onwards, the soil should be covered in order to keep it dry and prevent clay lumps forming once again.

2.7.2 Mixing of soil, cement and water

This stage of the production process initially involves the dry mixing together of the main constituent materials, before wet mixing with water to hydrate the OPC. The sufficient distribution of OPC throughout the soil, and the homogeneity and uniformity of the resulting block, can be significantly affected by the procedures adopted at the mixing stage (Chanda and Vipin, 2014).

The main operations during the mixing stage include: proportioning out, dry mixing and wet mixing.

Proportioning out of soil and cement in their dry state is the first crucial step which requires care. The total volume of the separate dry ingredients to be mixed should be based on practical criteria (Adam and Agib, 2001). From experience,

the proportioning criteria are normally based on the hourly output of the press being used. This means blocks have to be produced in separate batches, requiring mixes to be prepared only in sufficient quantity to be consumed by the press within approximately one hour's operation. Large batches are undesirable for several reasons. If larger batches are mixed without immediate compaction following, the water may evaporate causing the cement to set prematurely. This can easily be expected especially in hot tropical climates (Spence and Cook, 1983). Moreover, with large batches, it is also very difficult to achieve an even and homogeneous mix. Use of large batches also increases the risk of moisture variations developing in a mix. OPC is known to set within about 45 minutes (Lea, 1970). If within this time the wet mix has not yet been compacted, then a significantly weakened block might be produced (Lunt, 1980). Moreover, as cement is usually scarce and therefore expensive in developing countries, wastage of the binder through premature setting should be foreseeable and avoidable. This can be done as stated earlier by proportioning materials based on batch sizes that can be compacted within an hour.

Proportioning out of dry soil and cement can be done either by weight, or by volume measurements (Adam and Agib, 2001).

Following proportioning, the soil and cement should be mixed in two separate stages; first in a dry physical state, then in a wet state, in that order. Dry state mixing is best done by spreading the cement evenly over the spread out dry soil.

After dry mixing to uniform colour, water can then be added to the still dry soil and cement mix. The purpose of the water is to hydrate the cement and to enable the mix to be compacted at optimum moisture content (Rigassi, 1995). Determination of the right amount of water (Optimum water content) must have been done before this stage. Both dry and wet mixing should ideally be done within 3 to 4 minutes (Houben and Guillaud, 1994; Rigassi, 1995).

2.7.3 Compressing the damp soil and cement mix

Compressing the damp soil and cement mix is a key stage in the production of CSEBs. The effect of cement stabilization of soil is significantly enhanced by compressing it (Gooding and Thomas, 1995). Compression reduces voids by driving off air and any excess water from the damp soil and cement mix. The combined expulsion of air and water, and the squeezing of the solid particles together increases the density of the mix. Uncompressed soil-cement mix of the same mass prior to moulding may have density ranging between 1000 kg/m^3 and 1400 kg/m^3 (Norton, 1997). After compression, the increase in density for the same mass of mix is between 30% and 120%, commonly ranging between 1700 kg/m^3 and 2200 kg/m^3 (Houben and Guillaud, 1994). Higher densities are associated with improved compressive strength (Norton, 1997). The compression stage involves four distinct steps, namely: mould filling, moulding, demoulding, and handling of the green blocks (Rigassi, 1995). Underestimation of any of these four steps can lead to the production of

inferior blocks of low compressive strength.

The damp soil-cement mix has to be correctly measured out before filling the mould. Any slight variations in the amount of mix fed into the mould can result in blocks of differing densities and sizes. Cases of differences in density are normally associated with fixed-volume type of compression machines while size variations with fixed- pressure ones (Lunt, 1980). The two types of errors are cumulative and should be minimized or avoided completely. To do this, the amount of damp soil-cement mix to be filled into the mould should be strictly controlled. This can be achieved by measuring out the exact amount of mix to be placed into the mould each time using either a graduated bucket, scoop, or measuring box of fixed volume (Fitzmaurice, 1958). Measurement by weight, though considerably slower, can also be done. Presses equipped with adjustable measuring devices which either use sliding valves or tipping boxes are extremely rare. Whichever method is adopted, the important point is to ensure that the correct amount of mix, and of even moisture content, is fed into the mould each time.

2.7.4 Curing of the green blocks

Curing of the green blocks may be the last stage in the production process but remains one of the most consequential. As stated earlier, the strength of CSEBs, as with almost all concrete products in which OPC is used, increases with age (ILO and UNIDO, 1984). The hardening of OPC takes

time, and so will the development of strength in a block. For the OPC to harden normally, it requires the continued presence of moisture in a block which enables it to complete the hydration process. Insufficient w/c ratio and low degree of hydration can result in considerably weak blocks. If the green block is not allowed to retain sufficient moisture, then the hydration process will have been interfered with. This can result in unsatisfactory blocks of low strength and poor performance (Enteiche and Augusta, 1964).

The objective of the curing stage is therefore to ensure that moisture still in the block is allowed to facilitate the hydration process and to come out gradually and evenly. The two variables during curing that can affect this objective are the duration (time) and conditions (wet, dry, temperature, relative humidity, wind) (Freidin and Erell, 1995). The curing duration is often dictated by the specifications for the type of binder used for OPC the recommended length of time is usually 28days (ILO and UNIDO, 1984). Curing conditions specifically refer to the microenvironment in which the green blocks are placed.

In practice various methods are used to ensure proper curing. Such methods include the use of plastic bags, grass, leaves, etc., to prevent moisture from escaping. After two or three days, depending, on the local temperatures, cement stabilized blocks complete their primary cure. They can then be removed from their protective cover and stacked in a pile (Keefe, 2005).

As the stack of blocks is built up, the top layer should always be wetted and covered and the lower layer should be allowed to air-dry to achieve maximum

strength (Lunt, 1980).

2.8 CONCRETE MIX OPTIMIZATION METHODS

Prediction of concrete strength has been an active area of research and a considerable number of studies have been carried out. A number of improved prediction techniques have been proposed by several authors including empirical or computational modeling and statistical techniques.

2.8.1 Computational modeling

Many attempts have been made in the prediction of concrete strength through the use of computational techniques such as finite element analysis but the computational complexity of the models is prohibitive in many cases, requiring non proprietary mathematical tools.

2.8.2 Statistical techniques

A lot of research has been done on using multivariable regression models to improve the accuracy of concrete strength predictions. Statistical models have the attraction that once fitted they can be used to perform predictions much more quickly than other modeling techniques and are correspondingly simpler to implement in software. Apart from its speed, statistical modeling has the advantage over other techniques that are mathematically rigorous and can be used to define confidence interval for predictions.

2.8.2.1 Scheffe's simplex design

Henry Scheffe (1958, 1963) developed a theory for experiments with mixture of which the property studied depends on the proportions of the components present

and not on the quantity of the mixture. Scheffe showed that if q represents the number of constituent components of the mixture, the space of the variables known also as the factor space is a $(q - 1)$ dimensional simplex lattice. The composition may be expressed as molar weight, or volume fraction or percentage. A simplex lattice is a structural representation of lines or planes joining the assumed coordinates (points) of the constituent materials of the mixture. The points within a simplex lattice (factor space) are symmetrically arranged and equidistant from the centroid. In the design a suitable polynomial will be chosen to represent the response surface of the entire space. The number of points on the space corresponds to the number of parameters in the chosen polynomial equation. The difference between the simplex lattice and simplex centroid design is: in simplex lattice design the points considered either falls at the vertices of the factor space or at the edges, while in the centroidal design one of the points must fall at the center of the factor space.

2.8.2.2 Osadebe's concrete optimization model

According to Osadebe (2003), concrete is a four- component composite produced by mixing water, cement, fine aggregate (sand) and coarse aggregate. These ingredients are mixed in reasonable proportions to achieve desired strength of the concrete. This theory assumed that the response function is continuous and differentiable with respect to its variables, Z_i hence, it can be expanded using Taylor's series in the neighbourhood of a chosen point $Z^{(0)} = Z_1^{(0)} + Z_2^{(0)} + Z_3^{(0)} + Z_4^{(0)} + Z_5^{(0)}$ as follows $F(Z) = \sum F^M (Z_0) * (Z_i - Z_0)^m / M!$

2.8.2.3 Ibearugbulem's regression equation

Osadebe's and Scheffe's models differ from Ibearugbulem's model in that both methods have predetermined number of experiments to be carried out in order to formulate them. These predetermined observation points determine the mix ratios that can be used in them. Hence, they cannot be used to optimize an already conducted series of laboratory tests. Ibearugbulem's regression model has been formulated to take care of these inherent problems in Scheffe's and Osadebe's model (Ibearugbule et.al, 2003). The formulation of Ibearugbulem's model started with Osadebe's procedure and Scheffe's and Osadebe's constraints were imposed on it.

2.9 TESTS FOR GOODNESS OF FIT OF THE MODELS

The goodness of fit (GOF) of a statistical model describes how well it fits into a set of observations. GOF indices summarize the discrepancy between the observed values and the values expected under a statistical model (Geoffrey and Scott, 2011).

It is expected that the results of the models will be accepted with about 95% confidence of being correct or 5% risk of being incorrect. The results being correct mean that there is no difference between the models results and experimental test results.

The statistical hypothesis for accepting or otherwise the adequacy of the models results are as follows:

- i. Null Hypothesis (H_0): There is no significant difference between the models results and experimental test results.
- ii. Alternative Hypothesis (H_1): There is a significant difference between the models results and the experimental test results.

The risk involved is that 5% or below of the models results will be wrongly predicted.

Several methods of testing the adequacy of models results exist. Some of the known methods are Least Square method, Chi-Square method, Z – test method, Student t-test method, Fisher test method etc.

2.9.1 Fisher test

The formulation of a model for predicting mix ratios where desired response is known and vice versa, involves the generation of a mathematical equation with unknown coefficients and carrying out experimental tests to generate the unknown coefficients. This means that response can be got by the experimental test that uses replicates and as well as from the model when the coefficients are known. It is vital that the variance S_T^2 from the model be compared with the variance S_E^2 from the experimental test. (NIST, 2012) devised a means of comparing S_E^2 and S_T^2 through the use Fisher test. The equation for Fisher test is given as:

$$F = S_1^2 / S_2^2 \tag{2.1}$$

S_1^2 is the greater of S_E^2 and S_T^2 .

The range of S_1^2 / S_2^2 for which S_E^2 and S_T^2 are similar is given as

$$1 / F\alpha (v_1, v_2) < S_1^2 / S_2^2 < F\alpha (v_1, v_2) \quad (2.2)$$

Where

α is significant level and v is the degree of freedom = $N - 1$

CHAPTER THREE

MATERIALS AND METHOD

3.1 DESCRIPTION OF MATERIALS

Five basic materials were used for this work, namely laterite, river sand, granitic chippings, OPC and water.

The laterite was brought from a borrow pit in Obinze, it was free from deleterious materials, it has an approximate composition of, 83% sand and 17% clay/silt. It is classified as poorly graded clayey soil according to the unified soil classification system. It has inorganic clay of medium plasticity.

The river sand used in this work was also brought from Obinze, it was free from deleterious materials, it has a specific gravity of 2.6 and bulk density of 1675kg/m^3 when compacted and 1429kg/m^3 when loose.

The granite chippings used was 9.5mm uniform size aggregate, it was bought from a stone market in Owerri. It has an average crushing value of 25.87%.

The water was bought from a borehole close to the materials laboratory; it was clean and fit for drinking. The stabilizer was Ordinary Portland cement.

All laboratory investigations on materials were carried out in the Imo State Ministry of works and housing soil mechanics and materials laboratory.

For all laboratory tests attempts were made to ensure that the results obtained satisfied three basic conditions: accuracy, reliability and reproducibility. Only

standard methods were used in the production of the compressed stabilized earth blocks.

3.2 SOIL TESTS

Soil classification tests were carried out on the laterite in order to determine its category amongst other soils. The main tests conducted include the following: sieve analysis, liquid limit, plastic limit test, moisture content test, and plasticity index test.

The procedures involved in the tests are described below.

3.2.1 Sieve analysis

A dry representative sample of the soil was collected and poured into the tray of the weighing machine and the mass was weighed and recorded. At this point the sieves were stacked in order of decreasing size, the 4.75mm sieve was at the top of the stack followed by the 2.36mm sieve, 1.18mm sieve, 600um, 425um, 300 um, 212 um, 150 um, 75 um and the collector at the bottom of the stack. The weighed soil sample was then broken down to individual particles by hand and placed on top of the sieves. The set of sieves was then shaken until no more material passed from one sieve to the next. Soil particles lying on top of each sieve were then carefully removed and weighed. The weight of the materials retained on each sieve was converted to a percentage of the total mass hence giving a simple particle size analysis.

3.2.2 Atterberg limits

These tests provide an indication of the properties of the soil fraction finer than 0.425mm; it was carried out in accordance to AASHTO specifications. The equipment used for the tests are: Casagrande apparatus, grooving tool, 0.425mm sieve, flexible blade, glass plate and mass measurement balance.

A dry sample of the soil was pounded in a mortar to break up any agglomerations of particles; it was then sieved through sieve 0.425mm. The following two tests were performed on this soil sample.

3.2.3 Liquid limit

80g of an air-dried sample of the soil passing through 0.425mm sieve was taken in a dish and mixed with distilled water to form a uniform paste. A portion of the paste was placed in the cup of the Casagrande apparatus, and the surface was smoothed and leveled with a spatula to a maximum depth of 1cm. A groove was cut through the sample along the symmetrical axis of the cup using the Casagrande tool. The handle of the Casagrande apparatus was then turned at a rate of 2 revolutions per second until the two parts of the soil sample came into contact at the bottom of the groove along a distance of 12mm. The number of drops (blows) required to close the groove was recorded (a valid test is one in which 15 to 35 blows are required to close the groove). A sample of the soil was then taken to determine its moisture content.

The soil in the cup was again mixed and the test was repeated.

3.2.4 Plastic limit

About 15g of the sieved soil sample was mixed thoroughly with distilled water in an evaporating dish till the soil mass became plastic enough to be easily molded with fingers. The soil was then rolled into a ball with the hand and divided into roughly two equal parts. Each part of the soil was moulded into a cylinder of about 6mm and then rolled between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of 3mm diameter throughout its length. The rolling was continued until the soil threads crumbled at 3mm diameter.

The crumbled soil pieces was gathered together and placed into a pre-weighed air-tight container. The test was then repeated with the next soil sample. When all the samples had been tested, the sealed container's mass was weighed and recorded and re-weighed after oven drying the sample. The percentage of water as a fraction of the soil sample was calculated as the plastic limit of the soil.

3.2.5 Plasticity index

The plasticity index was obtained by subtracting the plastic limit from the liquid limit.

3.2.6 Compaction test

The compaction method used was the standard proctor compaction method. This test was done to determine the optimum moisture content and the maximum dry density of the laterite.

The following apparatus were used:-

(i) A Cylindrical mould of 105mm internal diameter and 115.5mm effective height with a detachable baseplate and a removable extension. (ii) A metal rammer having a 50mm diameter circular face, and weighing 2.5kg. (iii) 20mm BS sieve and receiver. (iv) Measuring scale. (v) A large metal tray (vi) extruder.

5.5kg of the air-dried and pulverized soil passing the 20mm BS sieve was taken. Water was added to the soil to bring its water content to 4%. The soil was thoroughly mixed for about five minutes. The mould was cleaned, dried and greased lightly. The mass of the empty mould with the base plate, but without the collar was determined. The collar was then fitted to the mould. The mould was placed on a solid base on the laboratory floor and filled with the soil to about one-third its height. The soil was compacted by 25 blows of the rammer with a free fall of 300mm. The blows were evenly distributed over the surface. The soil surface was scratched with a spatula before a second layer was placed. The mould was filled to about two-thirds of its height with the soil and compacted again by 25 blows. Likewise the third layer was placed and compacted. The collar was removed, and the soil was trimmed off to flush with the top of the mould. The mass of the mould, base plate and the compacted soil was taken and thus the mass of the compacted soil was determined. The bulk density of the soil was computed from the mass of the compacted soil and volume of the mould. Representative soil samples were taken from the mould to determine the moisture content.

The soil removed from the mould was broken with hand. More water was added to the soil so as to increase the water content by 2%. It was thoroughly mixed and

the test was repeated. The procedure was continued until the value of the bulk density dropped.

3.3 PREPARATION OF THE CSEB SAMPLES

The procedures adopted and precautions taken to produce the CSEBs used in this research work are described in this section. The description is based on the four main stages of CSEBs production: soil preparation, mixing, moulding and curing. Soil preparation involved the collection, drying and storage of the laterite and river sand. The soils were supplied in 25kg bags; they were removed from the bags and spread out on the hard, flat concrete laboratory floor. The spread out soils were regularly and repeatedly raked and turned over for about eight days. When both the bottom and top layers of the soils achieved uniform colouration, they were considered to be dry enough. The dry samples were then stored in bags and kept in a dry area of the laboratory. There was no need to screen the soil samples, the few dirt that were found in the samples were removed by hand.

The modified soil earth used for this work were obtained by mixing various proportions of laterite, river sand and granite of known properties as shown on Table 3.1. The proportions of each of the components (Laterite, river sand and granite) in each mix was selected using Table 2.3 as a guide. The earth samples were stabilized with OPC to obtain the cement-clay/silt-sand-gravel proportions shown on Table 3.2.

Mixing of the laterite, river sand, granite chippings, stabilizer (OPC) and water was done in three stages for each batch. The key objective during the mixing stage

was to ensure a good distribution of the stabilizer and water throughout the mix. Consistent proportioning out, dry mixing and wet mixing were required to obtain proper samples. The proportioning out of all the materials was done by weight, not by volume. All mixing (wet and dry mixing) was done on the laboratory floor. Dry mixing was done for about four minutes. After this, water was then added to the dry mix and the process was repeated. The amount of water used was 10%, which represents the optimum moisture content of the laterite.

After uniform mixing of the materials, the moulds were filled. Mould filling was done after first cleaning the mould using engine oil. There was no delay between mixing and moulding.

Compression of the damp mix was done using universal compression machine at a pressure of 6MPa for all the blocks. The improvisation was made because of unavailability of a standard CSEB moulding machine. The force monitoring gauge attached to the machine was used to determine the amount of force applied as required. The procedures were repeated till the required number of blocks (three) were produced for each mix type, all the blocks have the same size of 15mm x 15mm x 15mm.

After the blocks were made, demoulding and handling followed. This was done with great care as the blocks were still green. The blocks were then labelled using a permanent marker. This was done to identify each block by date of manufacture and mix type, a total of eighty one blocks were produced. The blocks were then

covered with a polythene sheet and were continually kept moist by sprinkling with water morning and evening until they were crushed.

Table 3.1: Mixture proportions for the modified earth

Mixture Label	Laterite (kg)	River sand (kg)	Granite (kg)
N1	24.08	0	4.515
N2	22.575	1.505	4.515
N3	21.82	2.258	4.515
N4	20.318	3.763	4.515
N5	19.565	4.515	4.515
N6	18.06	6.02	4.515
N7	24.453	0	3.762
N8	23.199	1.254	3.762
N9	22.01	2.445	3.762
N10	20.691	3.762	3.762
N11	19.563	4.891	3.762
N12	18.339	6.113	3.762
N13	25.08	0	2.508
N14	23.826	1.254	2.508
N15	22.572	2.508	2.508
N16	21.318	3.762	2.508
N17	20.064	5.016	2.508
N18	18.81	6.27	2.508
C1	22.274	1.806	4.515
C2	17.157	6.773	4.666
C3	18.813	5.418	4.365
C4	22.572	1.881	3.762
C5	21.256	3.198	4.326
C6	18.81	5.643	3.762
C7	19.56	5.52	2.508
C8	20.816	4.264	2.508
C9	19.061	6.019	2.508

Table 3.2: Mixture proportions of cement, clay/silt, sand and gravel

Mixture label	Cement(Kg)	Clay/silt (Kg)	Sand(Kg)	Gravel(Kg)
N1	1.505	4.094	19.986	4.515
N2	1.505	3.838	20.242	4.515
N3	1.505	3.710	20.370	4.515
N4	1.505	3.454	20.626	4.515
N5	1.505	3.326	20.754	4.515
N6	1.505	3.070	21.010	4.515
N7	1.881	4.157	20.296	3.762
N8	1.881	3.944	20.509	3.762
N9	1.881	3.741	20.712	3.762
N10	1.881	3.517	20.936	3.762
N11	1.881	3.326	21.127	3.762
N12	1.881	3.122	21.331	3.762
N13	2.508	4.264	20.816	2.508
N14	2.508	4.050	21.030	2.508
N15	2.508	3.837	21.243	2.508
N16	2.508	3.624	21.456	2.508
N17	2.508	3.411	21.669	2.508
N18	2.508	3.198	21.882	2.508
C1	1.505	3.793	20.293	4.515
C2	1.505	2.917	21.013	4.666
C3	1.505	3.198	21.032	4.365
C4	1.881	3.837	20.616	3.762
C5	1.881	3.613	20.841	3.762
C6	1.881	3.198	21.255	3.762
C7	2.508	3.336	21.744	2.508
C8	2.508	3.536	21.544	2.508
C9	2.508	3.235	21.845	2.508

3.4 REGRESSION MODELLING

The regression models were formulated based on Ibearugbulem et al. (2013) principles.

According to Osadebe (2003), concrete is a four- component composite produced by mixing water, cement, fine aggregate (sand) and coarse aggregate. These ingredients are mixed in reasonable proportions to achieve desired strength of the concrete.

Let us consider an arbitrary amount ‘S’ of a given mixture and let the portion of the *i*th component of the four constituent materials of the mixture be S_i , (where $i = 1, 2, 3, 4$). This was carried out with the principle of absolute mass.

Thus

$$S_1 + S_2 + S_3 + S_4 = S \quad (3.1)$$

Where S_1, S_2, S_3, S_4 are the quantities of cement, clay/silt, sand and gravel

Dividing Eqn (3.1) through by S gives

$$S_1/S + S_2/S + S_3/S + S_4/S = 1 \quad (3.2)$$

Where S_i/S is the proportion of the *i*th constituent component of the considered block mixture.

$$\text{Let } S_i/S = Z_i, \quad i = 1, 2, 3, 4 \quad (3.3)$$

Substituting Eqn (3.3) into Eqn (3.2) yields:

$$Z_1 + Z_2 + Z_3 + Z_4 = 1 \quad (3.4)$$

where Z_1, Z_2, Z_3, Z_4 are the fractional proportions of cement, clay/silt, sand, and gravel respectively.

For any given block mixture, exists a vector Z_i (Z_1, Z_2, Z_3, Z_4) whose elements satisfy Eqn (3.4). Also, for each value of Z_i , the following inequality holds:

$$Z_i > 0 \quad (3.5)$$

The compressive strength ‘Y’ of the blocks can be expressed mathematically as:

$$Y = f(Z_1, Z_2, Z_3, Z_4) \quad (3.6)$$

where $f(Z_1, Z_2, Z_3, Z_4)$ is a multi-variate response function whose variables Z_i are subject to the constraints as defined in Equations (3.4) and (3.5).

Osadebe (2003) assumed that the response function is continuous and differentiable with respect to its variables Z_i , hence it can be expanded with Taylor’s series in the neighborhood of a chosen point $Z^{(0)} = Z_1^{(0)} + Z_2^{(0)} + Z_3^{(0)} + Z_4^{(0)}$ as follows:

$$F(z) = \sum_{0 \leq m \leq \infty} F^m(z_0) \cdot (z_i - z_0)^m / m! \quad (3.7)$$

Where m is the degree of the polynomial and $F(z)$ is the response function.

Since $F^m(z_0)$ is the derivative of the function $F(z_0)$ to m degree, equation (3.7)

can be rewritten as in equation (3.8).

$$F(z) = \sum_{0 \leq m \leq \infty} \frac{d^m F(z_0)}{dz_0^m} \cdot (z_i - z_0)^m / m! \quad (3.8)$$

The number of terms in equation (3.8) is dependent on the degree of the polynomial, m , and the number of independent variables, i . Taking m equal to 1, equation (3.8) can be written as in equation (3.9).

$$F(Z) = \frac{\sum_{0 \leq m \leq \infty} \frac{d^0 F(z_0)}{dz_0^0} \cdot \frac{(z_i - z_0)^0}{0!}}{0!} + \frac{\sum_{2 \leq m \leq \infty} \frac{d F(z_0)}{dz_0} \cdot \frac{(z_i - z_0)}{1!}}{1!} \quad (3.9)$$

If m is equal to 2, then equation (3.9) will be as shown in equation (3.10).

$$F(Z) = \frac{\sum d^0 F(z_0)}{dz_0^0} \cdot \frac{(z_i - z_0)^0}{0!} + \frac{\sum d F(z_0)}{dz_0} \cdot \frac{(z_i - z_0)}{1!} + \frac{\sum d^2 F(z_0)}{dz_0^2} \cdot \frac{(z_i - z_0)^2}{2!} + \frac{\sum d^2 F(z_0)}{dz_0^2} \cdot \frac{(z_i - z_0)(z_i - z_j)}{2!} \quad (3.10)$$

$$0 \leq m \leq \infty, 2 \leq m \leq \infty$$

It is assumed that the origin is z_0 , which is equal to zero. Since the products and quotients of constants are constants, this equation can be written as equation (3.11).

$$F(z) = \sum b_m \cdot z_i^m \quad (3.11)$$

$$0 \leq m \leq \infty, 2 \leq m \leq \infty$$

from equation (3.11) it can be seen that:

$$\text{For } m = 0, b_m = b \quad (3.12)$$

$$\text{For } m = 1, b_m = b_i \quad (3.13)$$

$$\text{For } m = 2, b_m = b_{ii} \text{ (for } z_i^2 \text{ term)} \quad (3.14)$$

$$b_m = b_{ij} \text{ (for } z_i z_j \text{ term)} \quad (3.15)$$

$$\text{For } m = 3, b_m = b_{iii} \text{ (for } z_i^3 \text{ term)} \quad (3.16)$$

$$b_m = b_{ijk} \text{ (for } z_i z_j z_k \text{ term)} \quad (3.17)$$

$$b_m = b_{ijj} \text{ (for } z_i^2 z_j \text{ term)} \quad (3.18)$$

$$b_m = b_{ijj} \text{ (for } z_i z_j^2 \text{ term)} \quad (3.19)$$

$$b_m = b_{iik} \text{ (for } z_i^2 z_k \text{ term)} \quad (3.20)$$

$$b_m = b_{ikk} \text{ (for } z_i z_k^2 \text{ term)} \quad (3.21)$$

$$b_m = b_{jjk} \text{ (for } z_j^2 z_k \text{ term)} \quad (3.22)$$

$$b_m = b_{jkk} \text{ (for } z_j z_k^2 \text{ term)} \quad (3.23)$$

Equation (3.11) can also be written as;

$$F(z) = b_0 + \sum_{1 \leq m \leq \infty} b_m \cdot z_i^m \quad (3.24)$$

$$\text{For } i = n, 1 \leq m \leq n \quad (3.25)$$

(Scheffe, 1950) and (Osadebe and Ibearugbulem, 2008) restricted the summation of the independent variables to unity,

$$\sum z_i = 1 \quad (3.26)$$

Multiplying equation (3.26) by b_0 gives equation (3.27)

$$b_0 = \sum b_0 z_i \quad (3.27)$$

Multiplying equation (3.26) by z_i and rearranging gives;

$$z_i^2 = z_i - z_1 z_i - z_2 z_i - \dots - z_n z_i \quad (3.28)$$

Multiplying equation (3.26) by z_i^r and rearranging gives;

$$z_i^{r+1} = z_i^r - z_1 z_i^r - z_2 z_i^r - \dots - z_n z_i^r \quad (3.29).$$

Taking the highest degree of the polynomial and substituting equations (3.27) and (3.29) into equation (3.24) and factorizing, making sure that every term has no independent variable of more than one degree gives the Ibearugbulem's regression function, equation (3.30).

$$F(z) = \sum \alpha_i z_i + \sum \alpha_{ij} z_i z_j + \sum \alpha_{ijk} z_i z_j z_k + \dots + \sum \alpha_{ijk\dots\infty} z_i z_j z_k \dots z_\infty \quad (3.30)$$

$$1 \leq i \leq \infty, 1 \leq i \leq j \leq \infty, 1 \leq i \leq j \leq k \leq \infty, \dots, 1 \leq i \leq j \leq k \leq \dots \leq \infty$$

Where, $F(z)$ is the response function at any observation point z_i, z_j and z_k are the predictors, α_i, α_{ij} and α_{ijk} are the coefficients of the regression function.

For $i = 2$, equation (3.30) can be expressed as equation (3.31)

$$F(z) = \alpha_1 z_1 + \alpha_2 z_2 + \alpha_{12} z_1 z_2 \quad (3.31)$$

For $i = 3$, equation (3.30) can be expressed as equation (3.32)

$$F(z) = \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_{12} z_1 z_2 + \alpha_{13} z_1 z_3 + \alpha_{23} z_2 z_3 \\ + \alpha_{123} z_1 z_2 z_3 \quad (3.32)$$

For $i = 4$ equation (3.30) can be expressed as (3.33)

$$F(z) = \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \alpha_{12} z_1 z_2 + \alpha_{13} z_1 z_3 + \alpha_{14} z_1 z_4 + \alpha_{23} z_2 z_3 \\ + \alpha_{24} z_2 z_4 + \alpha_{34} z_3 z_4 + \alpha_{123} z_1 z_2 z_3 + \alpha_{124} z_1 z_2 z_4 + \alpha_{134} z_1 z_3 z_4 + \alpha_{234} z_2 z_3 z_4 \\ + \alpha_{1234} z_1 z_2 z_3 z_4 \quad (3.33)$$

The independent variables used in the regression function, equation (3.30) are pseudo variables. They are not the actual variables. However, a relationship exists between the pseudo variables, z_i and the actual variables, s_i .

$$z_i = s_i/s \quad (3.34)$$

$$s = \sum s_i \quad (3.35)$$

3.5 THE COEFFICIENTS OF THE REGRESSION FUNCTION

Summing equation (3.30) for n observation points gives

$$\sum_{\substack{\mathbf{r} \\ 1 \leq r \leq n}} F(z) = \sum_{\mathbf{r}} \alpha_i z_i + \sum_{\mathbf{r}} \alpha_{ij} z_i z_j + \dots \quad (3.36)$$

Multiplying (3.36) by z_w gives

$$\sum_{\substack{\mathbf{r} \\ 1 \leq r \leq n}} z_w * F(z) = \sum_{\mathbf{r}} \alpha_i z_i * z_w + \sum_{\mathbf{r}} \alpha_{ij} z_i z_j * z_w + \dots \quad (3.37)$$

Multiplying (3.36) by $z_q z_s z_t$ gives

$$\sum_{\substack{r \\ 1 \leq r \leq n}} z_q z_s z_t * F(z) = \sum_r \sum_r \alpha_{i z_i * z_q z_s z_t} + \sum_r \sum_r \alpha_{ij z_i z_j * z_q z_s z_t} + \dots \quad (3.38)$$

adding equations (3.37) and (3.38) gives n simultaneous equations with n unknowns, represented in a matrix form as shown in equation (3.39)

$$\begin{bmatrix} \sum_r z_1 * F(z) \\ \sum_r z_2 * F(z) \\ \sum_r z_3 * F(z) \\ \vdots \\ \vdots \\ \sum_{\substack{r \\ r \leq 1 \leq n}} z_1 z_2 z_3 \dots * F(z) \end{bmatrix} = \begin{bmatrix} \sum_r z_1 * z_1 & \sum_r z_2 * z_1 & \sum_r z_3 * z_1 & \dots \\ \sum_r z_1 * z_2 & \sum_r z_2 * z_2 & \sum_r z_3 * z_2 & \dots \\ \sum_r z_1 * z_3 & \sum_r z_2 * z_3 & \sum_r z_3 * z_3 & \dots \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ \sum_r z_1 * z_1 * z_2 \dots & & \sum_r z_3 * z_1 * z_3 \dots & \dots \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \vdots \\ \vdots \\ \alpha_{123} \end{bmatrix} \quad (3.39)$$

Solving equation (3.39) gives the values of the coefficients of the regression function in equation (3.30). Equation (3.39) can be written in a short form as shown in equation (3.40)

$$[F(z) * Z] = [CC] [\alpha] \quad (3.40)$$

Where CC is always a symmetric matrix.

Equation (3.33) with a 15×15 CC matrix will be used as the equation for the first model, increasing the terms of equation 3.32 to 23 and 26 gives the equations for the second and third models with CC matrices of 23×23 and 26×26 respectively as shown in Appendices B and C. The model equations are as shown:

Model one:

$$\begin{aligned}
 F(z) = & \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \alpha_{12} z_1 z_2 + \alpha_{13} z_1 z_3 + \\
 & \alpha_{14} z_1 z_4 + \alpha_{23} z_2 z_3 + \alpha_{24} z_2 z_4 + \alpha_{34} z_3 z_4 + \alpha_{123} z_1 z_2 z_3 + \\
 & \alpha_{124} z_1 z_2 z_4 + \alpha_{134} z_1 z_3 z_4 + \alpha_{234} z_2 z_3 z_4 + \alpha_{1234} z_1 z_2 z_3 z_4
 \end{aligned} \tag{3.40a}$$

Model two:

$$\begin{aligned}
 F(z) = & \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_{12} z_1 z_2 + \alpha_{13} z_1 z_3 + \alpha_{23} z_2 z_3 + \\
 & \alpha_{123} z_1 z_2 z_3 + \alpha_{11} z_1 z_1 + \alpha_{22} z_2 z_2 + \alpha_{33} z_3 z_3 + \alpha_{112} z_1 z_1 z_2 + \\
 & \alpha_{113} z_1 z_1 z_3 + \alpha_{122} z_1 z_2 z_2 + \alpha_{133} z_1 z_3 z_3 + \alpha_{223} z_2 z_2 z_3 + \\
 & \alpha_{233} z_2 z_3 z_3 + \alpha_{1122} z_1 z_1 z_2 z_2 + \alpha_{1133} z_1 z_1 z_3 z_3 + \alpha_{2233} z_2 z_2 z_3 z_3 \\
 & + \alpha_{11223} z_1 z_1 z_2 z_2 z_3 + \alpha_{11233} z_1 z_1 z_2 z_3 z_3 + \alpha_{12233} z_1 z_2 z_2 z_3 z_3 \\
 & + \alpha_{112233} z_1 z_1 z_2 z_2 z_3 z_3
 \end{aligned} \tag{3.40b}$$

Model three:

$$\begin{aligned}
 F(z) = & \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_{12} Z_1 Z_2 + \alpha_{13} Z_1 Z_3 + \alpha_{23} Z_2 Z_3 + \\
 & \alpha_{123} Z_1 Z_2 Z_3 + \alpha_{11} Z_1 Z_1 + \alpha_{22} Z_2 Z_2 + \alpha_{33} Z_3 Z_3 + \alpha_{112} Z_1 Z_1 Z_2 \\
 & + \alpha_{113} Z_1 Z_1 Z_3 + \alpha_{122} Z_1 Z_2 Z_2 + \alpha_{133} Z_1 Z_3 Z_3 + \alpha_{223} Z_2 Z_2 Z_3 + \\
 & \alpha_{233} Z_2 Z_3 Z_3 + \alpha_{1122} Z_1 Z_1 Z_2 Z_2 + \alpha_{1123} Z_1 Z_1 Z_2 Z_3 + \alpha_{1133} Z_1 Z_1 Z_3 Z_3 + \\
 & \alpha_{1223} Z_1 Z_2 Z_2 Z_3 + \alpha_{1233} Z_1 Z_2 Z_3 Z_3 + \alpha_{2233} Z_2 Z_2 Z_3 Z_3 + \\
 & \alpha_{11223} Z_1 Z_1 Z_2 Z_2 Z_3 + \alpha_{11233} Z_1 Z_1 Z_2 Z_3 Z_3 + \alpha_{12233} Z_1 Z_2 Z_2 Z_3 Z_3 + \\
 & \alpha_{112233} Z_1 Z_1 Z_2 Z_2 Z_3 Z_3
 \end{aligned} \tag{3.40c}$$

Table 3.6 shows the actual mixture proportions, S_i and the corresponding fractional portions, Z_i , for the mixes used to formulate the models. S_1, S_2, S_3 and S_4 represent the mix ratios for cement, clay/silt, sand and gravel respectively. The values of the fractional portions will be used to develop the Z matrices for each of the three models. While Table 3.7 shows values of the actual mix proportions and the fractional portions of the mixes that will be used to test the adequacy of the models. These set of mix proportions will be called control mix proportions.

Table 3.6: Values of actual mix proportions and the corresponding fractional portions for mixes used to formulate the models

S/N	S ₁	S ₂	S ₃	S ₄	Z ₁	Z ₂	Z ₃	Z ₄
N1	1	2.72	13.28	3	0.05	0.136	0.664	0.15
N2	1	2.55	13.45	3	0.05	0.1275	0.6725	0.15
N3	1	2.465	13.535	3	0.05	0.12325	0.67675	0.15
N4	1	2.295	13.705	3	0.05	0.11475	0.68525	0.15
N5	1	2.21	13.79	3	0.05	0.1105	0.6895	0.15
N6	1	2.04	13.96	3	0.05	0.102	0.698	0.15
N7	1	2.21	10.79	2	0.0625	0.138125	0.674375	0.125
N8	1	2.097	10.903	2	0.0625	0.131063	0.681438	0.125
N9	1	1.989	11.011	2	0.0625	0.124313	0.688188	0.125
N10	1	1.87	11.13	2	0.0625	0.116875	0.695625	0.125
N11	1	1.768	11.232	2	0.0625	0.1105	0.702	0.125
N12	1	1.66	11.34	2	0.0625	0.10375	0.70875	0.125
N13	1	1.7	8.3	1	0.083333	0.141667	0.691667	0.083333
N14	1	1.615	8.385	1	0.083333	0.134583	0.69875	0.083333
N15	1	1.53	8.47	1	0.083333	0.1275	0.705833	0.083333
N16	1	1.445	8.555	1	0.083333	0.120417	0.712917	0.083333
N17	1	1.36	8.64	1	0.083333	0.113333	0.72	0.083333
N18	1	1.275	8.725	1	0.083333	0.10625	0.727083	0.083333

Table 3.7: Values of actual mix proportions and the corresponding fractional portions for mixes used to test the models

S/N	S ₁	S ₂	S ₃	S ₄	Z ₁	Z ₂	Z ₃	Z ₄
C1	1	2.52	13.484	3	0.05	0.126	0.6742	0.15
C2	1	1.938	13.962	3.1	0.05	0.0969	0.6981	0.155
C3	1	2.125	13.975	2.9	0.05	0.10625	0.69875	0.145
C4	1	2.04	10.96	2	0.0625	0.1275	0.685	0.125
C5	1	1.921	11.08	2	0.062496	0.120055	0.692457	0.124992
C6	1	1.7	11.3	2	0.0625	0.10625	0.70625	0.125
C7	1	1.33	8.67	1	0.083333	0.110833	0.7225	0.083333
C8	1	1.41	8.59	1	0.083333	0.1175	0.715833	0.083333
C9	1	1.29	8.71	1	0.083333	0.1075	0.725833	0.083333

As stated earlier S₁, S₂, S₃ and S₄ are the mix ratios for cement, clay/silt, sand and gravel.

Using the values of Z₁, Z₂, Z₃ and Z₄ the Z matrix shown in Appendix D, was obtained. Furthermore, substituting the values of the Z matrix into the CC matrix shown in Appendix A, gives the 15 X 15 CC matrix presented in tabular form in Appendix E. The inverse of the CC matrix is also presented in tabular form in Appendix F. The Z matrix for the control mixes was computed and presented in Appendix G.

All of these are for the first model. A similar process was followed to obtain the Z matrix, CC matrix, CC matrix inverse and Z matrix for the control mixes for

model two. These are presented in tabular form in Appendices H, I, J and K. Also the Z matrix, CC matrix, CC matrix inverse and Z matrix for the control mixes for model three were obtained and presented in Appendices L, M, N and O.

Having known the values of [CC] and [Z] matrices, the values of [α] can easily be determined.

From equation 3.40. Making [α] the subject of the equation gives

$$[\alpha] = [CC]^{-1} [F(z)*Z] \quad (3.41)$$

Expanding equation 3.41 gives

$$\begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \vdots \\ \vdots \\ \alpha_{123} \end{bmatrix} = \begin{bmatrix} \sum_r z_1^* z_1 & \sum_r z_2^* z_1 & \sum_r z_3^* z_1 & \dots \\ \sum_r z_1^* z_2 & \sum_r z_2^* z_2 & \sum_r z_3^* z_2 & \dots \\ \sum_r z_1^* z_3 & \sum_r z_2^* z_3 & \sum_r z_3^* z_3 & \dots \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ \sum_r z_1^* z_1^* z_2 \dots & & \sum_r z_3^* z_1^* z_3 \dots & \end{bmatrix}^{-1} \begin{bmatrix} \sum_r z_1^* F(z) \\ \sum_r z_2^* F(z) \\ \sum_r z_3^* F(z) \\ \vdots \\ \vdots \\ \sum_r z_1 z_2 z_3 \dots^* F(z) \end{bmatrix} \quad (3.42)$$

$$r \leq 1 \leq n$$

The values of [α] will be calculated in chapter four, by which time the practical tests would have been carried out and test results obtained.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 SIEVE ANALYSIS

The particle size distribution curve of Figure 4.1 shows that the laterite is poorly graded with a uniformity coefficient (C_u) and coefficient of curvature (C_c) of 1.12 and 0 respectively. It is classified as poorly graded clayey sand (SP, SC) under the Unified Soil Classification System (USCS). The curve also reveals that the soil falls into zone 3 of the fine aggregate grading curve.

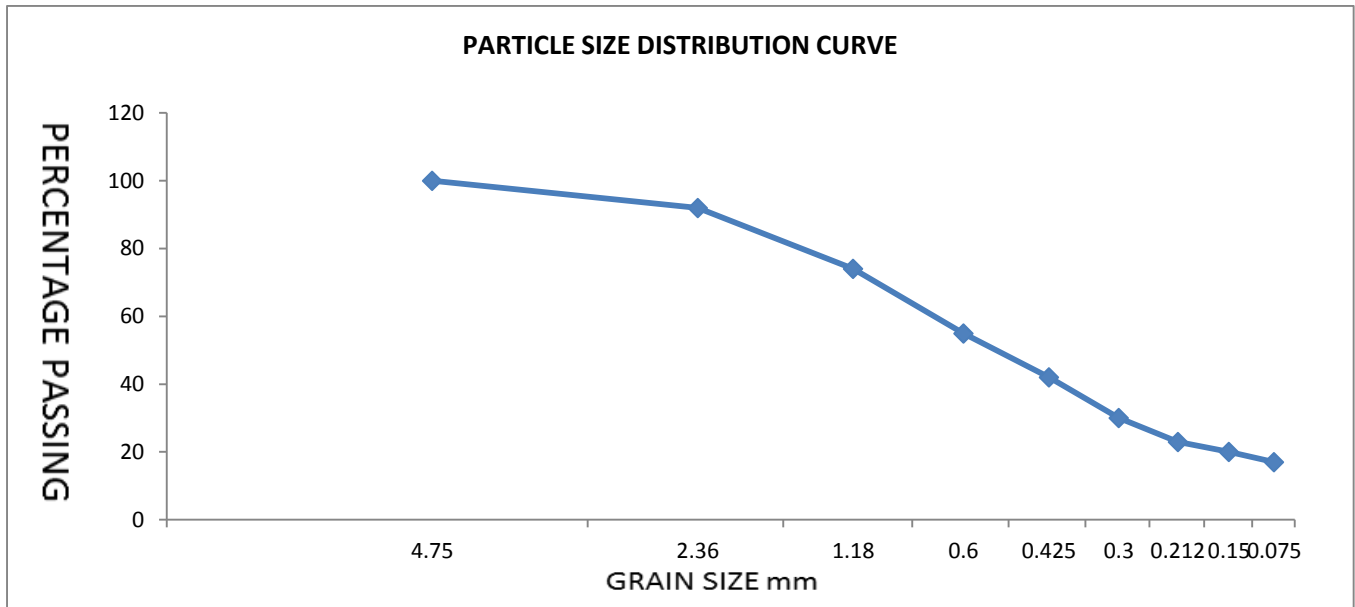


Figure 4.1: Particle size distribution curve of the laterite

4.2 ATTERBERG LIMITS

The results of the Atterberg limits test is shown in Figure 4.2. The laterite has a liquid limit of 35%, plastic limit of 24% and a plasticity index of 11%. This puts it in zone A-2-6 according to the AASHTO soil classification. The plasticity

index and the liquid limit converged above the A-line of the plasticity chart (See Appendix S), this implies that it has inorganic clay of medium plasticity.

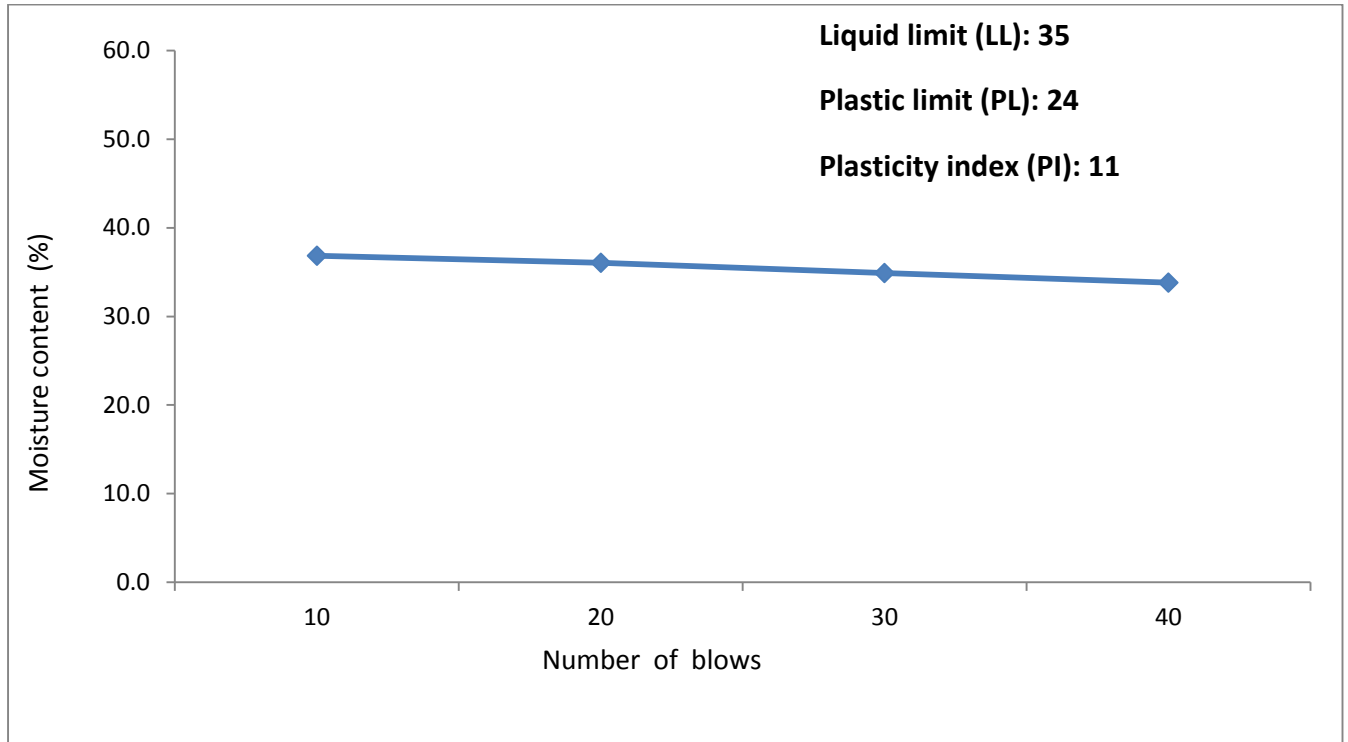


Figure 4.2 Liquid limit of the laterite

4.3 COMPACTION TEST

Figure 4.3 shows the compaction curve of the laterite, the curve is plotted between the water content as abscissa and the corresponding dry density as ordinate. It is observed that the dry density initially increases with an increase in water content till the maximum dry density 1990kg/m^3 is attained. With further increase in water content the dry density decreases. The water content corresponding to the maximum dry density (10%) is the optimum water content of the soil.

At water content lower than the optimum water content, the soil is stiff and has lot of void spaces and therefore, the dry density is low. As the water content is

increased, the soil particles get lubricated and slip over each other, and move into densely packed positions and the dry density is increased. However, at water content more than the optimum water content, the additional water reduces the dry density, as it occupies the space that might have been occupied by the soil particles.

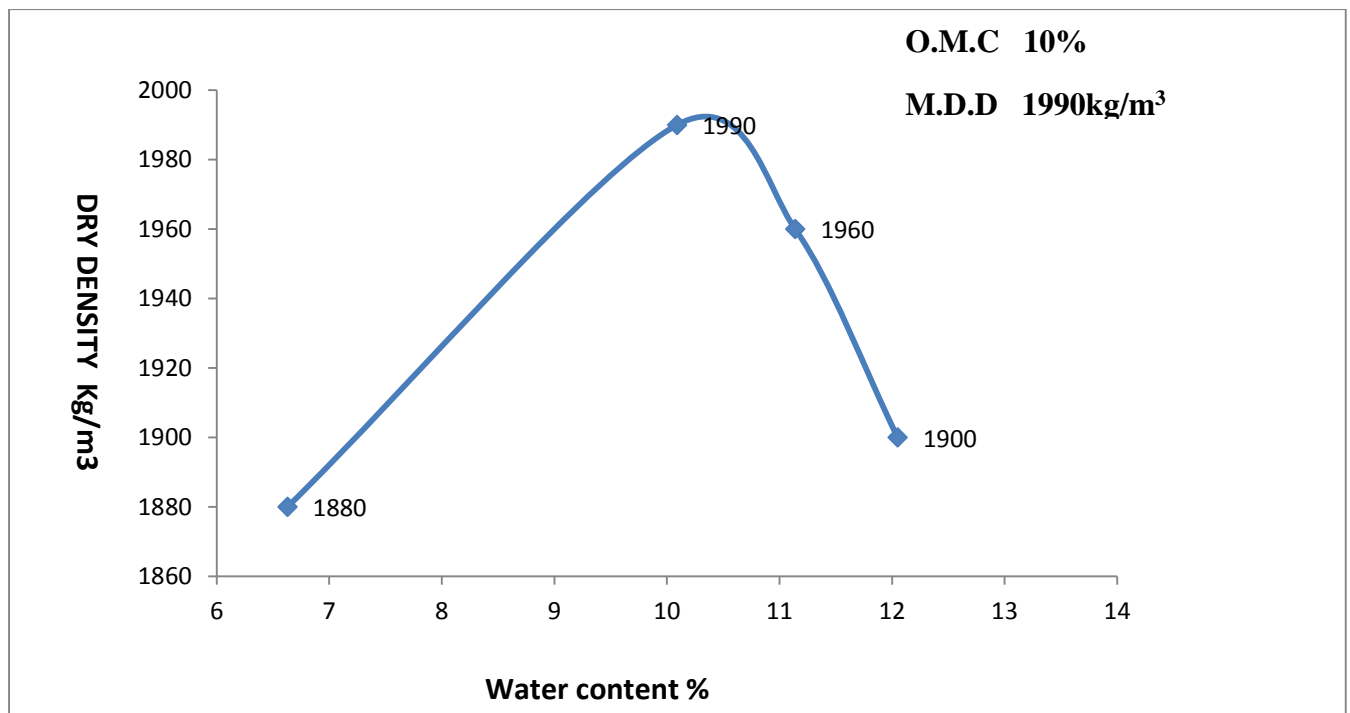


Fig 4.3 Compaction curve of the laterite

4.4 COMPRESSIVE STRENGTH

The 28th day compressive strength values of the compressed stabilized earth blocks are shown on Table 4.4.

Table 4.4: 28th day compressive strength of the compressed stabilized earth blocks

S/N	Observation points	% Cement content	Replicate 1	Replicate 2	Replicate 3	Mean compressive strength	Average Compressive Strength N/mm ²
1	N1	5%	3.60	2.76	3.33	3.23	3.63
2	N2		3.10	3.19	3.97	3.42	
3	N3		3.42	3.72	3.60	3.58	
4	N4		3.23	3.81	4.24	3.76	
5	N5		4.28	2.32	4.86	3.82	
6	N6		3.66	3.46	4.76	3.96	
7	N7	6%	4.13	5.42	5.57	5.04	5.50
8	N8		5.20	5.38	5.26	5.28	
9	N9		6.58	5.48	4.38	5.48	
10	N10		4.67	5.76	6.4	5.61	
11	N11		5.50	5.66	5.94	5.7	
12	N12		5.57	5.84	6.17	5.86	
13	N13	8%	6.58	6.10	5.98	6.22	6.84
14	N14		6.99	6.37	6.20	6.52	
15	N15		6.61	6.46	6.94	6.67	
16	N16		6.68	6.92	6.86	6.82	
17	N17		7.71	7.44	6.84	7.33	
18	N18		7.66	7.76	6.96	7.46	
19	C1		3.56	3.80	3.44	3.6	
20	C2		3.78	3.62	4.00	3.8	
21	C3		3.40	3.60	3.20	3.4	
22	C4		5.32	5.44	5.50	5.42	
23	C5		5.36	5.30	5.84	5.5	
24	C6		5.84	5.76	5.80	5.8	
25	C7		7.00	7.52	7.40	7.31	
26	C8		7.06	7.03	7.00	7.03	
27	C9		7.53	7.48	7.26	7.42	

Using the values of Z_i (Appendix D) and the 28th day compressive strength of the blocks on Table 4.4, $[F(z)*Z]$ for the first model was obtained as shown.

$$\sum(Z_1.F(z)) = 6.56746$$

$$\sum(Z_2.F(z)) = 11.59062$$

$$\sum(Z_3.F(z)) = 66.79684$$

$$\sum(Z_4.F(z)) = 10.80508$$

$$\sum(Z_1Z_2.F(z)) = 0.79752$$

$$\sum(Z_1Z_3.F(z)) = 4.59615$$

$$\sum(Z_1Z_4.F(z)) = 0.70571$$

$$\sum(Z_2Z_3.F(z)) = 8.07395$$

$$\sum(Z_2Z_4.F(z)) = 1.30261$$

$$\sum(Z_3Z_4.F(z)) = 7.50692$$

$$\sum(Z_1Z_2Z_3.F(z)) = 0.55736$$

$$\sum(Z_1Z_2Z_4.F(z)) = 0.08536$$

$$\sum(Z_1Z_3Z_4.F(z)) = 0.49193$$

$$\sum(Z_2Z_3Z_4.F(z)) = 0.90377$$

$$\sum(Z_1Z_2Z_3Z_4.F(z)) = 0.05942$$

The values of the coefficients $[\alpha]$ were obtained by substituting $[F(z)*Z]$ and the inverse of CC matrix (Appendix F) into equation 3.42. The values of the coefficients of model one are presented on Table 4.5

Table 4.5: values of the coefficients of model one

α_1	581.0913415
α_2	-199.6942908
α_3	-17.79905224
α_4	65.64284506
α_{12}	373.5689201
α_{13}	-406.4833456
α_{14}	-1442.163751
α_{23}	182.9133896
α_{24}	-5.278102161
α_{34}	-59.46731268
α_{123}	-1404.747879
α_{124}	15569.94455
α_{134}	2555.903156
α_{234}	166.9383361
α_{1234}	-14630.4259

From equation (3.40a), the model equation is given as:

$$\begin{aligned}
 F(z) = & 581.0913415Z_1 - 199.6942908Z_2 - 17.79905224Z_3 + \\
 & 65.64284506Z_4 + 373.5689201Z_1Z_2 - 406.4833456Z_1Z_3 \\
 & - 1442.163751Z_1Z_4 + 182.9133896Z_2Z_3 - 5.278102161Z_2Z_4 - \\
 & 59.46731268Z_3Z_4 - 1404.747879Z_1Z_2Z_3 + 15569.9446Z_1Z_2Z_4 \\
 & + 2555.903156Z_1Z_3Z_4 + 166.9383361Z_2Z_3Z_4 - 14630.4259Z_1Z_2Z_3Z_4
 \end{aligned} \tag{4.1}$$

Equation 4.1 is the mathematical model for predicting the compressive strength of compressed stabilized earth blocks compressed with a pressure of 6MPa for any observation point. It is referred to as model one in this work.

The compressive strength of the blocks predicted by model one was obtained by multiplying the coefficients of the regression model on Table 4.5 by the Z matrix of the mixes used in formulating the model (Appendix D) and the Z matrix of the control mixes (Appendix G). The predicted model compressive strength from model one is presented on Tables 4.6 and 4.7.

Table 4.6: Compressive strength from laboratory and model one, for mixes used in formulating the model

MIXTURE LABELS	MODEL ONE	LAB
N1	3.26	3.23
N2	3.45	3.42
N3	3.54	3.58
N4	3.72	3.76
N5	3.81	3.82
N6	3.99	3.96
N7	5.08	5.04
N8	5.25	5.28
N9	5.41	5.48

N10	5.59	5.61
N11	5.74	5.7
N12	5.90	5.86
N13	6.22	6.22
N14	6.47	6.52
N15	6.71	6.67
N16	6.96	6.82
N17	7.21	7.33
N18	7.46	7.46

Table 4.7: Compressive strength from laboratory and model one, for the control mixes

MIXTURE LABELS	C1	C2	C3	C4	C5	C6	C7	C8	C9
MODEL ONE	3.48	4.61	3.37	5.34	5.51	5.84	7.29	7.06	7.41
LAB	3.60	3.80	3.40	5.42	5.50	5.80	7.31	7.03	7.42

Where LAB = Laboratory

Similarly for Model two, using the values of Z_i (Appendix H) and the

28th day compressive strength of the blocks on Table 4.4, $[F(z)*Z]$ was obtained

as shown:

$\Sigma(Z_1.F(z))$	= 12.44971
$\Sigma(Z_2.F(z))$	= 71.74783
$\Sigma(Z_3.F(z))$	=11.56246
$\Sigma(Z_1Z_2.F(z))$	=9.32164
$\Sigma(Z_1Z_3.F(z))$	=1.49262
$\Sigma(Z_2Z_3.F(z))$	=8.60195
$\Sigma(Z_1Z_2Z_3.F(z))$	=1.10968
$\Sigma(Z_1Z_1.F(z))$	=1.63544
$\Sigma(Z_2Z_2.F(z))$	=53.82423
$\Sigma(Z_3Z_3.F(z))$	=1.46788
$\Sigma(Z_1Z_1Z_2.F(z))$	=1.22373
$\Sigma(Z_1Z_1Z_3.F(z))$	=0.19468
$\Sigma(Z_1Z_2Z_2.F(z))$	=6.98824
$\Sigma(Z_1Z_3Z_3.F(z))$	=0.18826
$\Sigma(Z_2Z_2Z_3.F(z))$	=6.40731
$\Sigma(Z_2Z_3Z_3.F(z))$	=1.08496
$\Sigma(Z_1Z_1Z_2Z_2.F(z))$	=0.91679
$\Sigma(Z_1Z_1Z_3Z_3.F(z))$	=0.02439
$\Sigma(Z_2Z_2Z_3Z_3.F(z))$	=0.80283
$\Sigma(Z_1Z_1Z_2Z_2Z_3.F(z))$	=0.10759
$\Sigma(Z_1Z_1Z_2Z_3Z_3.F(z))$	=0.01800
$\Sigma(Z_1Z_2Z_2Z_3Z_3.F(z))$	=0.10281
$\Sigma(Z_1Z_1Z_2Z_2Z_3Z_3.F(z))$	=0.01330

The values of the coefficient $[\alpha]$, obtained by substituting $[F(z)*Z]$ and the inverse of CC matrix (Appendix J), into equation 3.42, are presented on Table

4.8

Table 4.8: Values of the coefficients of model two

α_1	-18.57877196
α_2	28.67660543
α_3	20.48875944
α_{12}	-113.8324465
α_{13}	-43.53377525
α_{23}	-15.84438545
α_{123}	-213.4784134
α_{11}	-153.5286678
α_{22}	-2.137222531
α_{33}	-1017.283618
α_{112}	-105.6537952
α_{113}	-839.9065241
α_{122}	-57.93728914
α_{133}	569.3020963
α_{223}	-76.55461737
α_{233}	534.8190885
α_{1122}	794.746053
α_{1133}	-26569.4748
α_{2233}	495.5057295
α_{11223}	5631.66525
α_{11233}	17753.095
α_{12233}	3952.881341
α_{112233}	39742.59152

From equation 3.40b, the model equation is given as:

$$\begin{aligned}
 F(z) = & -18.57877196Z_1 + 28.67660543Z_2 + 20.48875944Z_3 - \\
 & 113.8324465Z_1Z_2 - 43.53377525Z_1Z_3 - 15.84438545Z_2Z_3 \\
 & - 213.4784134Z_1Z_2Z_3 - 153.5286678Z_1Z_1 - 2.137222531Z_2Z_2 - \\
 & 1017.283618Z_3Z_3 - 105.6537952Z_1Z_1Z_2 - 839.9065241Z_1Z_1Z_3 \\
 & - 57.93728914Z_1Z_2Z_2 + 569.3020963Z_1Z_3Z_3 - 76.55461737Z_2Z_2Z_3 + \\
 & 534.819088Z_2Z_3Z_3 + 794.746053Z_1Z_1Z_2Z_2 - 26569.4748Z_1Z_1Z_3Z_3 \\
 & + 495.5057295Z_2Z_2Z_3Z_3 + 5631.66525Z_1Z_1Z_2Z_2Z_3 + 17753.095Z_1Z_1Z_2Z_3Z_3 \\
 & + 3952.881341Z_1Z_2Z_2Z_3Z_3 + 39742.59152Z_1Z_1Z_2Z_2Z_3Z_3
 \end{aligned} \tag{4.2}$$

Equation 4.2 is the mathematical model for predicting the compressive strength of compressed stabilized earth blocks compressed with a pressure of 6Mpa for any observation point. It is referred to as model two in this work.

The compressive strength of the earth blocks predicted by model two, obtained by multiplying the coefficients of the regression model on Table 4.8 with the Z matrix of the mixes used in formulating the model (Appendix H) and the Z matrix of the control mixes (Appendix K), are presented on Table 4.9 and Table 4.10

Table 4.9: Compressive strength from laboratory and model two, for mixes used in formulating the model

MIXTURE LABELS	MODEL TWO	LAB
N1	3.21	3.23
N2	3.46	3.42
N3	3.57	3.58
N4	3.75	3.76
N5	3.82	3.82
N6	3.96	3.96
N7	5.08	5.04
N8	5.27	5.28
N9	5.43	5.48
N10	5.60	5.61
N11	5.73	5.7
N12	5.87	5.86
N13	6.22	6.22
N14	6.46	6.52
N15	6.70	6.67
N16	6.95	6.82
N17	7.21	7.33
N18	7.48	7.46

Table 4.10: Compressive strength from laboratory and model two, for the control mixes

MIXTURE LABELS	C1	C2	C3	C4	C5	C6	C7	C8	C9
MODEL TWO	3.50	3.50	4.38	5.36	5.53	5.81	7.30	7.05	7.43
LAB	3.60	3.80	3.40	5.42	5.50	5.80	7.31	7.03	7.42

Where LAB = Laboratory

For Model three, using the values of Z_i (Appendix L) and the 28th day compressive

strength of the blocks on Table 4.4, $[F(z)*Z]$ was obtained, as shown:

$\sum(Z_1.F(z))$	= 12.44971
$\sum(Z_2.F(z))$	=71.74783
$\sum(Z_3.F(z))$	=11.56246
$\sum(Z_1Z_2.F(z))$	=9.32164
$\sum(Z_1Z_3.F(z))$	=1.49262
$\sum(Z_2Z_3.F(z))$	=8.60195
$\sum(Z_1Z_2Z_3.F(z))$	=1.10968
$\sum(Z_1Z_1.F(z))$	=1.63544
$\sum(Z_2Z_2.F(z))$	=53.82423
$\sum(Z_3Z_3.F(z))$	=1.46788
$\sum(Z_1Z_1Z_2.F(z))$	=1.22373
$\sum(Z_1Z_1Z_3.F(z))$	=0.19468
$\sum(Z_1Z_2Z_2.F(z))$	=6.98824
$\sum(Z_1Z_3Z_3.F(z))$	=0.18826
$\sum(Z_2Z_2Z_3.F(z))$	=6.40731
$\sum(Z_2Z_3Z_3.F(z))$	=1.08496
$\sum(Z_1Z_1Z_2Z_2.F(z))$	=0.91679
$\sum(Z_1Z_1Z_2Z_3.F(z))$	=0.14464
$\sum(Z_1Z_1Z_3Z_3.F(z))$	=0.02439
$\sum(Z_1Z_2Z_2Z_3.F(z))$	=0.82600
$\sum(Z_1Z_2Z_3Z_3.F(z))$	=0.13904
$\sum(Z_2Z_2Z_3Z_3.F(z))$	=0.80283
$\sum(Z_1Z_1Z_2Z_2Z_3.F(z))$	=0.10759
$\sum(Z_1Z_1Z_2Z_3Z_3.F(z))$	=0.01800
$\sum(Z_1Z_2Z_2Z_3Z_3.F(z))$	=0.10281
$\sum(Z_1Z_1Z_2Z_2Z_3Z_3.F(z))$	=0.01330

The values of the coefficients $[\alpha]$, for model three obtained by substituting the values of $[F(z)*Z]$ above and the inverse of CC matrix (Appendix N) into equation 3.42, are presented on Table 4.11

Table 4.11: values of the coefficients of model three

α_1	-23.25641961
α_2	20.68243472
α_3	-2.979122914
α_{12}	-85.78312204
α_{13}	-20.19398375
α_{23}	48.15782188
α_{123}	-328.1156954
α_{11}	-140.3441538
α_{22}	3.727289688
α_{33}	-917.3071528
α_{112}	-186.1305881
α_{113}	-505.4710727
α_{122}	-67.45180632
α_{133}	370.0986794
α_{223}	-62.78894054
α_{233}	499.2672839
α_{1122}	911.7934166
α_{1123}	-887.1975017
α_{1133}	-22944.84557
α_{1223}	-154.6610251
α_{1233}	277.5024192
α_{2233}	174.1736678
α_{11223}	5965.841002
α_{11233}	3605.432961
α_{12233}	4878.012294
α_{112233}	54075.36719

From equation 3.40c, the model equation is given as:

$$\begin{aligned}
 F(z) = & -23.25641961Z_1 + 20.68243472Z_2 - 2.979122914Z_3 - \\
 & 85.78312204Z_1Z_2 - 20.19398375Z_1Z_3 + 48.15782188Z_2Z_3 - \\
 & 328.1156954Z_1Z_2Z_3 - 140.3441538Z_1Z_1 + 3.727289688Z_2Z_2 - \\
 & 917.3071528Z_3Z_3 - 186.1305881Z_1Z_1Z_2 - 505.4710727Z_1Z_1Z_3 \\
 & - 67.45180632Z_1Z_2Z_2 + 370.0986794Z_1Z_3Z_3 - 62.78894054Z_2Z_2Z_3 + \\
 & 499.2672839Z_2Z_3Z_3 + 911.7934166Z_1Z_1Z_2Z_2 - 887.1975017Z_1Z_1Z_2Z_3 - \\
 & 22944.84557Z_1Z_1Z_3Z_3 - 154.6610251Z_1Z_2Z_2Z_3 + 277.502419Z_1Z_2Z_3Z_3 \\
 & + 174.1736678Z_2Z_2Z_3Z_3 + 5965.841002Z_1Z_1Z_2Z_2Z_3 + \\
 & 3605.432961Z_1Z_1Z_2Z_3Z_3 + 4878.012294Z_1Z_2Z_2Z_3Z_3 + \\
 & 54075.36719Z_1Z_1Z_2Z_2Z_3Z_3
 \end{aligned} \tag{4.3}$$

Equation 4.3 is the mathematical model for predicting the compressive strength of compressed stabilized earth blocks compressed with a pressure of 6MPa for any observation point. It is referred to as model three in this work. The compressive strengths of the earth blocks predicted by model three, obtained by multiplying the coefficients of the regression model on Table 4.11 by the Z matrix of the mixes used in formulating the model (Appendix L) and the Z matrix for the control mixes (Appendix O), are presented on Tables 4.12 and 4.13.

Table 4.12: Compressive strength from laboratory and model three for mixes used in formulating the model

MIXTURE LABELS	MODEL THREE	LAB
N1	3.20	3.23
N2	3.50	3.42
N3	3.60	3.58
N4	3.70	3.76
N5	3.80	3.82
N6	4.00	3.96
N7	5.10	5.04
N8	5.30	5.28
N9	5.40	5.48
N10	5.60	5.61
N11	5.70	5.70
N12	5.90	5.86
N13	6.20	6.22
N14	6.50	6.52
N15	6.70	6.67
N16	6.90	6.82
N17	7.20	7.33
N18	7.50	7.46

TABLE 4.13: Compressive strength from laboratory and model three for the control mixes

MIXTURE LABELS	C1	C2	C3	C4	C5	C6	C7	C8	C9
MODEL THREE	3.51	3.48	4.38	5.36	5.53	5.82	7.30	7.05	7.42
LAB	3.60	3.80	3.40	5.42	5.50	5.80	7.31	7.03	7.42

Where LAB = Laboratory

4.5 FISHER TEST TO CHECK THE ACCURACY OF THE MODELS USING THE CONTROL MIXES

Fisher, f- test was carried out to determine whether there is significant difference between the values of the compressive strength of the blocks from the laboratory and those predicted from each of the models. The results are shown on Tables 4.14, 4.15 and 4.16.

Table 4.14: Fisher test on the compressive strength from model one using the control mixes

RESPONSE SYMBOL	Y _L	Y _M	Y _L - \bar{y}_L	Y _M - \bar{y}_M	(Y _L - \bar{y}_L) ²	(Y _M - \bar{y}_M) ²
C1	3.60	3.48	-1.8756	-2.0690	3.5177	4.2807
C2	3.80	4.61	-1.6756	-0.9372	2.8075	0.8783
C3	3.40	3.37	-2.0756	-2.1761	4.3079	4.7356
C4	5.42	5.34	-0.0556	-0.2087	0.0031	0.0435
C5	5.50	5.51	0.0244	-0.0344	0.0006	0.0012
C6	5.80	5.84	0.3244	0.2954	0.1053	0.0873
C7	7.31	7.29	1.8344	1.7489	3.3652	3.0585
C8	7.03	7.06	1.5544	1.5141	2.4163	2.2925
C9	7.42	7.41	1.9444	1.8670	3.7809	3.4855
TOTAL	49.28	49.901			20.3044	18.8630
MEAN	5.48	5.54				

LEGEND $\bar{y}_L = \sum Y_L / N$, $\bar{y}_M = \sum Y_M / N$, $N = 9$ ($Y_L = Y_{LAB}$, $Y_M = Y_{MODEL}$)

$$S_E^2 = \sum (Y_L - \bar{y}_L)^2 / (N-1) = 20.3044 / (9-1) = 2.5381$$

$$S_T^2 = \sum (Y_M - \bar{y}_M)^2 / (N-1) = 18.8630 / (9-1) = 2.3579$$

Therefore $S_1^2 = 2.5381$ and $S_2^2 = 2.3579$

$$F_{\text{calculated}} = S_1^2/S_2^2 = 2.5381/2.3579 = 1.076$$

F from statistic tables is given as $F_{\infty}(V_1, V_2)$

This is equal to $F_{0.05}(8,8)$

From Appendix T, $F_{0.05}(8,8) = 3.44$, $1/F = 0.2907$

Thus the condition $1/F < S_1^2/S_2^2 < F$, which is $0.2907 < 1.076 < 3.44$ has been satisfied

The difference between laboratory result and model result is not significant

Table 4.15: Fisher test on the compressive strength from model two using the control mixes

RESPONSE SYMBOL	Y_L	Y_M	$Y_L - \bar{y}_L$	$Y_M - \bar{y}_M$	$(Y_L - \bar{y}_L)^2$	$(Y_M - \bar{y}_M)^2$
C1	3.60	3.50	-1.8756	-2.0400	3.5177	4.1616
C2	3.80	3.50	-1.6756	-2.0400	2.8075	4.1616
C3	3.40	4.38	-2.0756	-1.1600	4.3079	1.3456
C4	5.42	5.36	-0.0556	-0.1800	0.0031	0.0324
C5	5.50	5.53	0.0244	-0.0100	0.0006	0.0001
C6	5.80	5.81	0.3244	0.2700	0.1053	0.0729
C7	7.31	7.30	1.8344	1.7600	3.3652	3.0976
C8	7.03	7.05	1.5544	1.5100	2.4163	2.2801
C9	7.42	7.43	1.9444	1.8900	3.7809	3.5721
TOTAL	49.28	49.86			20.3044	18.7240
MEAN	5.48	5.54				

LEGEND $\bar{y}_L = \sum Y_L / N$, $\bar{y}_M = \sum Y_M / N$, $N = 9$ ($Y_L = Y_{\text{LAB}}$, $Y_M = Y_{\text{MODEL}}$)

$$S_E^2 = \sum (Y_L - \bar{y}_L)^2 / (N-1) = 20.3044 / (9-1) = 2.5381$$

$$S_T^2 = \sum (Y_M - \bar{y}_M)^2 / (N-1) = 18.724 / (9-1) = 2.3405$$

Therefore $S_1^2 = 2.5381$ and $S_2^2 = 2.3405$

$$F_{\text{calculated}} = S_1^2/S_2^2 = 2.5381/2.3405 = 1.084$$

F from statistic tables is given as $F_{\infty}(V_1, V_2)$

This is equal to $F_{0.05}(8,8)$

From Appendix T, $F_{0.05}(8,8) = 3.44$, $1/F = 0.2907$

Thus the condition $1/F \angle S_1^2/S_2^2 \angle F$, which is $0.2907 < 1.084 < 3.44$ has been satisfied

The difference between laboratory result and model result is not significant

Table 4.16: Fisher test on the compressive strength from model three using the control mixes

RESPONSE SYMBOL	Y _L	Y _M	Y _L - \bar{y}_L	Y _M - \bar{y}_M	(Y _L - \bar{y}_L) ²	(Y _M - \bar{y}_M) ²
C1	3.60	3.51	-1.8756	-2.0323	3.5177	4.1304
C2	3.80	3.48	-1.6756	-2.0571	2.8075	4.2317
C3	3.40	4.38	-2.0756	-1.1587	4.3079	1.3425
C4	5.42	5.36	-0.0556	-0.1802	0.0031	0.0325
C5	5.50	5.53	0.0244	-0.0072	0.0006	0.0001
C6	5.80	5.82	0.3244	0.2801	0.1053	0.0784
C7	7.31	7.30	1.8344	1.7573	3.3652	3.0881
C8	7.03	7.05	1.5544	1.5131	2.4163	2.2895
C9	7.42	7.42	1.9444	1.8851	3.7809	3.5536
TOTAL	49.28	49.86			20.3044	18.7468
MEAN	5.48	5.54				

LEGEND $\bar{y}_L = \sum Y_L / N$, $\bar{y}_M = \sum Y_M / N$, $N = 9$ ($Y_L = Y_{\text{LAB}}$, $Y_M = Y_{\text{MODEL}}$)

$$S_E^2 = \sum(Y_L - \bar{y}_L)^2 / (N-1) = 20.3044 / (9-1) = 2.5381$$

$$S_T^2 = \sum(Y_M - \bar{y}_M)^2 / (N-1) = 18.7468 / (9-1) = 2.3434$$

Therefore $S_1^2 = 2.5381$ and $S_2^2 = 2.3434$

$$F_{\text{calculated}} = S_1^2/S_2^2 = 2.5381/2.3434 = 1.083$$

F from statistic tables is given as $F_{\infty}(V_1, V_2)$

This is equal to $F_{0.05}(8,8)$

From Appendix T, $F_{0.05}(8,8) = 3.44$, $1/F = 0.2907$

Thus the condition $1/F < S_1^2/S_2^2 < F$ which is $0.2907 < 1.083 < 3.44$ has been satisfied

The difference between laboratory result and model result is not significant.

4.6 CORRELATION BETWEEN CLAY CONTENT, CEMENT CONTENT AND COMPRESSIVE STRENGTH.

The correlation between clay content, cement content and compressive strength of the blocks was examined. The 28th day compressive strength values of the blocks with clay content of 17%, 16%, 15%, 14% and 13% stabilized with 5%, 6% and 8% cement content are shown on Table 4.17 and graphically on Figures 4.4, 4.5, 4.6 and 4.7.

Table 4.17: Correlation between clay content, cement content and compressive strength

Clay content (%)	Compressive strength (N/mm ²)		
	5% cement content	6% cement content	8% cement content
17	3.23	5.04	6.22
16	3.42	5.28	6.52
15	3.58	5.48	6.67
14	3.76	5.61	6.82
13	3.96	5.86	7.46

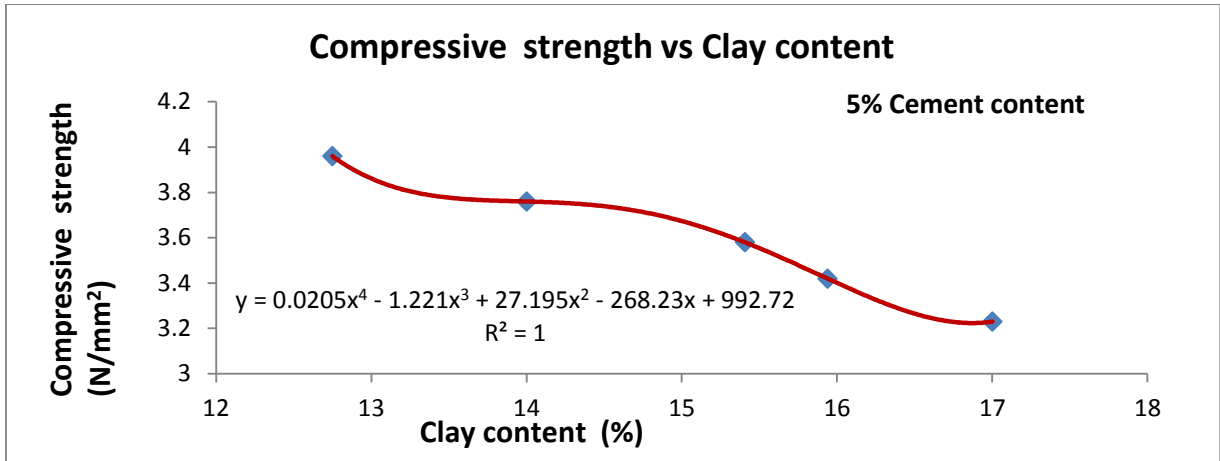


Figure 4.4: Compressive strength versus clay content for 5% cement content

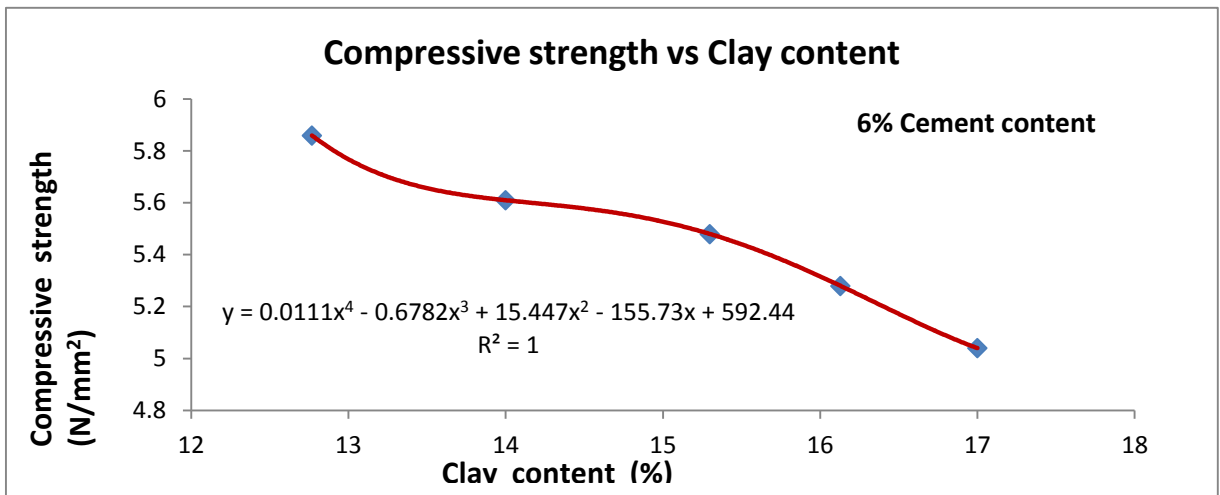


Figure 4.5: Compressive strength versus clay content for 6% cement content

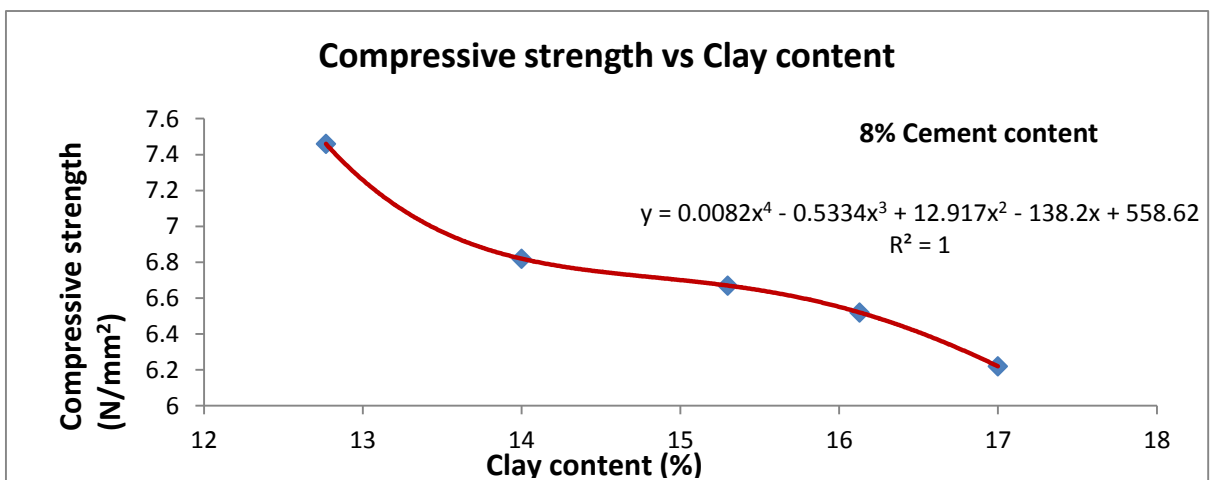


Figure 4.6: Compressive strength versus clay content for 8% cement content

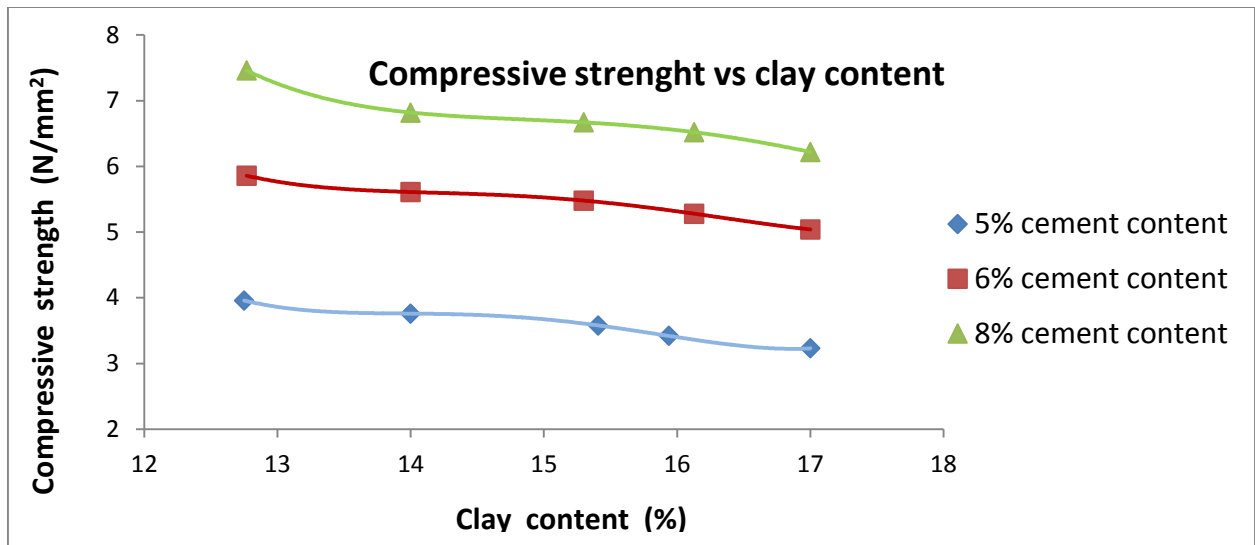


Figure 4.7: Compressive strength versus clay content for 5%, 6% and 8% cement content

It can be seen from Figures 4.4, 4.5, 4.6 and 4.7 that for a given level (%) of cement stabilization the compressive strength of the blocks decreased as the clay content increased. This is because while some clay particles bond with cement to form a matrix of reaction products, there are many unreacted clay particles that swell in contact with moisture, damaging the cement-clay matrix and causing the reduction in strength observed as the clay content increases. Some clay is needed in CSEBs because when the CSEBs mixture is moistened and compacted, the cement provides little to no initial strength as the blocks are removed from the press and transported for curing. The clay minerals as natural binding agents help in the handleability of CSEBs at this stage of the production process. But too much clay interferes with the reaction between cement and water, weakening the long term strength of the block. On the other hand, the compressive strength of the blocks increased with increase

in cement content as shown on Figure 4.7. As the cement content increases compressive strength increases. This confirms Rigassi (1995) that blocks with low cement content lack the impermeable matrix of calcium silicates that the cement provides. This results in free clay particles expanding and contracting, damaging the CSEBs and inducing the decrease in compressive strength observed in Figure 4.7 as the cement content decreases.

4.7 PERFORMANCE INDICES OF THE MIXES

The performance indices of the various mixes used to produce the blocks were checked to ascertain the performance of each mix irrespective of the cement content.

The performance index of each mix was gotten by dividing the compressive strength of the mix by the cement content as shown on Table 4.18.

$$\text{Performance Index (PI)} = \frac{\text{Compressive strength}}{\text{Cement content}} \quad (4.4)$$

Table 4.18: Performance indices of the mixes

5% CEMENT CONTENT						
MIXTURE LABEL	CEMENT	CLAY & SILT	SAND	GRAVEL	COMPRESSIVE STRENGTH (N/mm²)	PERFORMANCE INDEX (N/mm²/%cement content)
N1	1	2.72	13.28	3	3.23	0.646
N2	1	2.55	13.45	3	3.42	0.684
N3	1	2.47	13.54	3	3.58	0.716
N4	1	2.30	13.71	3	3.76	0.752
N5	1	2.21	13.79	3	3.82	0.764
N6	1	2.04	13.96	3	3.96	0.792
C1	1	2.52	13.48	3	3.6	0.720
C2	1	1.94	13.96	3.1	3.8	0.760
C3	1	2.12	13.97	2.9	3.4	0.680

6% CEMENT CONTENT						
MIXTURE LABEL	CEMENT	CLAY & SILT	SAND	GRAVEL	COMPRESSIVE STRENGTH (N/mm²)	PERFORMANCE INDEX (N/mm²/%cement content)
N7	1	2.21	10.79	2	5.04	0.84
N8	1	2.10	10.90	2	5.28	0.88
N9	1	1.99	11.01	2	5.48	0.91
N10	1	1.87	11.13	2	5.61	0.94
N11	1	1.77	11.23	2	5.7	0.95
N12	1	1.66	11.34	2	5.86	0.98
C4	1	2.04	10.96	2	5.42	0.90
C5	1	1.92	11.08	2	5.5	0.92
C6	1	1.70	11.30	2	5.8	0.97
8% CEMENT CONTENT						
MIXTURE LABEL	CEMENT	CLAY & SILT	SAND	GRAVEL	COMPRESSIVE STRENGTH (N/mm²)	PERFORMANCE INDEX (N/mm²/%cement content)
N13	1	1.70	8.30	1	6.22	0.78
N14	1	1.62	8.39	1	6.52	0.82
N15	1	1.53	8.47	1	6.67	0.83
N16	1	1.45	8.56	1	6.82	0.85
N17	1	1.36	8.64	1	7.33	0.92
N18	1	1.28	8.73	1	7.46	0.93
C7	1	1.33	8.67	1	7.31	0.91
C8	1	1.41	8.59	1	7.03	0.88
C9	1	1.29	8.71	1	7.42	0.93

From Table 4.18 it can be seen that mixture N12 with mix ratio of 1.66:11.34:2, for clay, sand and gravel respectively has the highest performance index and therefore recommended for the production of high strength CSEBs.

It can also be observed that the mixes with 6% cement content have the highest performance index. Thus, for high performance CSEBs, it is recommended that cement content be restricted to 6% which is the optimum cement content.

Furthermore mixes with 8% cement content performed better than those with 5% cement content.

The observed findings are very important for this research as they indicate that strength of earth blocks do not depend on cement content alone, rather it depends on the constituent components of the soil.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research has shown that laterite can be used to produce blocks of high strength when it is stabilized with cement and compressed with pressure as low as 6MPa. Increase in cement content resulted in an increase in the compressive strength of the blocks made at the same constant compaction pressure. Blocks made with 5%, 6% and 8% cement content gave average compressive strengths of 3.63N/mm², 5.50N/mm² and 6.84N/mm² respectively, well above the 2.5N/mm² recommended by the Nigeria Industrial Standard for load bearing walls.

Mixture N12 which has a mixture proportion of; 1.66:11.34:2, for clay, sand and gravel respectively has the highest performance index. This represents 76% sand, 11% clay, and 13% gravel, therefore soils with this composition are recommended for the production of high strength CSEBs.

All the three models were tested for adequacy using the Fisher test on the nine (9) control mixtures. There were no significant difference between the strengths predicted by the models and the corresponding experimental results. With the models any desired strength of CSEBs moulded with a compactive pressure of 6MPa, given any mix proportions can be easily determined.

5.2 RECOMMENDATIONS

- (i) Earth can be used to make blocks of high compressive strength when it is stabilized and compressed. Significant cost cut can be achieved in low cost housing projects especially in storey buildings when the blocks are used as load bearing walls.
- (ii) All the three Models formulated in this research work can be used in confidence to predict the 28th day compressive strength of stabilized earth blocks compressed with a pressure of 6MPa when the mixture proportions are known.
- (iii) Since the models have the same degrees of accuracy it is recommended that the first model which takes shorter time to solve, be used in the prediction of the compressive strength of CSEBs compressed with a pressure of 6MPa.
- (iv) Future research works should develop models for predicting other CSEB responses in addition to the 28th day compressive strength when the mixture proportions are known.
- (v) Future research works should investigate the feasibility of producing high strength CSEBs using waste materials like periwinkle shell, palm kernel shell and palm kernel fiber as raw materials.
- (vi) Future research works should repeat this present study using compactive stresses other than 6MPa used herein.
- (vii) Future research works should repeat this present study using 3%, 4% and 7% cement content.

(viii) Future research works should investigate the feasibility of improving the properties of CSEBs by the addition of cement replacement materials like; rice husk ash, ground-granulated blast furnace slag, and fly ash.

5.3 CONTRIBUTIONS TO KNOWLEDGE

This study came up with three different models for predicting the compressive strength of CSEBs moulded with 6MPa compactive pressure. Another contribution of this study is the presentation of performance indices of various CSEBs from which it was confirmed that a CSEB with 6% cement, 76% sand, 11% clay, and 13% gravel has optimum performance.

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APPENDIX A

Table 3.3: Matrix showing elements of CC matrix for Model one

	1	2	3	4	5	6
1	$\sum\sum Z_1 Z_1$	$\sum\sum Z_1 Z_2$	$\sum\sum Z_1 Z_3$	$\sum\sum Z_1 Z_4$	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_3$
2	$\sum\sum Z_1 Z_2$	$\sum\sum Z_2 Z_2$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3$
3	$\sum\sum Z_1 Z_3$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_3 Z_3$	$\sum\sum Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3$
4	$\sum\sum Z_1 Z_4$	$\sum\sum Z_2 Z_4$	$\sum\sum Z_3 Z_4$	$\sum\sum Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_3 Z_4$
5	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
6	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_4$	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_4$
8	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
9	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_2 Z_2 Z_4$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$
10	$\sum\sum Z_1 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_3 Z_3 Z_4$	$\sum\sum Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4$
11	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$
13	$\sum\sum Z_1 Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_4$
14	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$	$Z_1 Z_2 Z_3 Z_3 Z_4$
15	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4$

Table 3.3: Matrix showing elements of CC matrix for Model one continued

	7	8	9	10	11
1	$\sum\sum Z_1 Z_1 Z_4$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
2	$\sum\sum Z_1 Z_2 Z_4$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_4$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3$
3	$\sum\sum Z_1 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
4	$\sum\sum Z_1 Z_4 Z_4$	$\sum\sum Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_4 Z_4$	$\sum\sum Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$
5	$\sum\sum Z_1 Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
6	$\sum\sum Z_1 Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$
8	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_2 Z_3$
9	$\sum\sum Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_2 Z_4 Z_4$	$\sum\sum Z_3 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$
10	$\sum\sum Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$
11	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4$
13	$\sum\sum Z_1 Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4$
14	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_4$
15	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_4$

Table 3.3: Matrix showing elements of CC matrix for Model one continued

	12	13	14	15
1	$\sum\sum Z_1 Z_1 Z_2 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$
2	$\sum\sum Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$
3	$\sum\sum Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$
4	$\sum\sum Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$
5	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4$
6	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4$
7	$\sum\sum Z_1 Z_1 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4 Z_4$
8	$\sum\sum Z_1 Z_2 Z_3 Z_2 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_2 Z_3 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_2 Z_3 Z_4$
9	$\sum\sum Z_1 Z_2 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$
10	$\sum\sum Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$
11	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_4$
12	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$
13	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$
14	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_4 Z_4$
15	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_4 Z_4$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_4 Z_4$

Table 3.4: Matrix showing elements of CC matrix for Model two

	1	2	3	4
1	$\sum\sum Z_1 Z_1$	$\sum\sum Z_1 Z_2$	$\sum\sum Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2$
2	$\sum\sum Z_1 Z_2$	$\sum\sum Z_2 Z_2$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2$
3	$\sum\sum Z_1 Z_3$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$
5	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
6	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$
7	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1$	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2$
9	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2$
10	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$
12	$\sum\sum Z_1 Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$
14	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$
16	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$
18	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$

Table 3.4: Matrix showing elements of CC matrix for Model two continued

	5	6	7	8
1	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1$
2	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2$
3	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2$
5	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3$
6	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1$
9	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$
10	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2$
12	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$
14	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
16	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$
18	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$
19	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$

Table 3.4: Matrix showing elements of CC matrix for Model two continued

	9	10	11	12
1	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_3$
2	$\sum\sum Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
3	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$
4	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_3$
5	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$
6	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3$
9	$\sum\sum Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
10	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$
12	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$
13	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
14	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$
15	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
16	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
18	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$
19	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$

Table 3.4: Matrix showing elements of CC matrix for Model two continued

	13	14	15	16
1	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
2	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$
3	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$
4	$\sum\sum Z_1 Z_2 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$
5	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$
6	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
9	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$
10	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
14	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
16	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$
19	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$

Table 3.4: Matrix showing elements of CC matrix for Model two continued

	17	18	19	20
1	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
2	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
3	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
4	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_2 Z_2 Z_3$
5	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
6	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
9	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
10	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
14	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
16	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_2 Z_2 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$

Table 3.4: Matrix showing elements of CC matrix for Model two continued

	21	22	23
1	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
2	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
3	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
4	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
5	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
6	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
9	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
10	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
14	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
16	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$

APPENDIX C

Table 3.5: Matrix showing elements of CC matrix for Model three

	1	2	3	4
1	$\sum\sum Z_1 Z_1$	$\sum\sum Z_1 Z_2$	$\sum\sum Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2$
2	$\sum\sum Z_1 Z_2$	$\sum\sum Z_2 Z_2$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2$
3	$\sum\sum Z_1 Z_3$	$\sum\sum Z_2 Z_3$	$\sum\sum Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$
5	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
6	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1$	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2$
9	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2$
10	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$
12	$\sum\sum Z_1 Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$
14	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$
16	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$
18	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
21	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
22	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	5	6	7	8
1	$\sum\sum Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1$
2	$\sum\sum Z_1 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2$
3	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2$
5	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3$
6	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1$
9	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$
10	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2$
12	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$
14	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
16	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$
18	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
21	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
22	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	9	10	11	12
1	$\sum\sum Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_3$
2	$\sum\sum Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3$
3	$\sum\sum Z_2 Z_2 Z_3$	$\sum\sum Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3$
4	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$
5	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$
6	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3$
9	$\sum\sum Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
10	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$
12	$\sum\sum Z_1 Z_1 Z_3 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$
13	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
14	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$
15	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
16	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
18	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
21	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
22	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
24	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
25	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	13	14	15	16
1	$\sum\sum Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3$
2	$\sum\sum Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$
3	$\sum\sum Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$
5	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$
6	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$
9	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$
10	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_3 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
14	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
16	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	17	18	19	20
1	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$
2	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3$
3	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$
4	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
5	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
6	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
9	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
10	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
14	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
16	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	21	22	23
1	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
2	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
3	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
4	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
5	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
6	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3$
9	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
10	$\sum\sum Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
14	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
16	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$

Table 3.5: Matrix showing elements of CC matrix for Model three continued

	24	25	26
1	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
2	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
3	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
4	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
5	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
6	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
7	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
8	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$
9	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
10	$\sum\sum Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
11	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$
12	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$
13	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
14	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
15	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
16	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
17	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3$
18	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
19	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
20	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
21	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
22	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
23	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3$
24	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
25	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$
26	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$	$\sum\sum Z_1 Z_1 Z_1 Z_1 Z_2 Z_2 Z_2 Z_2 Z_3 Z_3 Z_3 Z_3$

Table 3.8: Z Matrix for Model one**APPENDIX D**

S/N	Z ₁	Z ₂	Z ₃	Z ₄	Z ₁ Z ₂	Z ₁ Z ₃	Z ₁ Z ₄
N1	0.050000	0.136000	0.664000	0.150000	0.006800	0.033200	0.007500
N2	0.050000	0.127500	0.672500	0.150000	0.006375	0.033625	0.007500
N3	0.050000	0.123250	0.676750	0.150000	0.006163	0.033838	0.007500
N4	0.050000	0.114750	0.685250	0.150000	0.005738	0.034263	0.007500
N5	0.050000	0.110500	0.689500	0.150000	0.005525	0.034475	0.007500
N6	0.050000	0.102000	0.698000	0.150000	0.005100	0.034900	0.007500
N7	0.062500	0.138125	0.674375	0.125000	0.008633	0.042148	0.007813
N8	0.062500	0.131063	0.681438	0.125000	0.008191	0.042590	0.007813
N9	0.062500	0.124313	0.688188	0.125000	0.007770	0.043012	0.007813
N10	0.062500	0.116875	0.695625	0.125000	0.007305	0.043477	0.007813
N11	0.062500	0.110500	0.702000	0.125000	0.006906	0.043875	0.007813
N12	0.062500	0.103750	0.708750	0.125000	0.006484	0.044297	0.007813
N13	0.083333	0.141667	0.691667	0.083333	0.011806	0.057639	0.006944
N14	0.083333	0.134583	0.698750	0.083333	0.011215	0.058229	0.006944
N15	0.083333	0.127500	0.705833	0.083333	0.010625	0.058819	0.006944
N16	0.083333	0.120417	0.712917	0.083333	0.010035	0.059410	0.006944
N17	0.083333	0.113333	0.720000	0.083333	0.009444	0.060000	0.006944
N18	0.083333	0.106250	0.727083	0.083333	0.008854	0.060590	0.006944

Table 3.8: Z Matrix for Model one continued

S/N	Z_2Z_3	Z_2Z_4	Z_3Z_4	$Z_1Z_2Z_3$	$Z_1Z_2Z_4$	$Z_1Z_3Z_4$	$Z_2Z_3Z_4$	$Z_1Z_2Z_3Z_4$
N1	0.090304	0.020400	0.099600	0.004515	0.001020	0.004980	0.013546	0.000677
N2	0.085744	0.019125	0.100875	0.004287	0.000956	0.005044	0.012862	0.000643
N3	0.083409	0.018488	0.101513	0.004170	0.000924	0.005076	0.012511	0.000626
N4	0.078632	0.017213	0.102788	0.003932	0.000861	0.005139	0.011795	0.000590
N5	0.076190	0.016575	0.103425	0.003809	0.000829	0.005171	0.011428	0.000571
N6	0.071196	0.015300	0.104700	0.003560	0.000765	0.005235	0.010679	0.000534
N7	0.093148	0.017266	0.084297	0.005822	0.001079	0.005269	0.011644	0.000728
N8	0.089311	0.016383	0.085180	0.005582	0.001024	0.005324	0.011164	0.000698
N9	0.085550	0.015539	0.086023	0.005347	0.000971	0.005376	0.010694	0.000668
N10	0.081301	0.014609	0.086953	0.005081	0.000913	0.005435	0.010163	0.000635
N11	0.077571	0.013813	0.087750	0.004848	0.000863	0.005484	0.009696	0.000606
N12	0.073533	0.012969	0.088594	0.004596	0.000811	0.005537	0.009192	0.000574
N13	0.097986	0.011806	0.057639	0.008166	0.000984	0.004803	0.008166	0.000680
N14	0.094040	0.011215	0.058229	0.007837	0.000935	0.004852	0.007837	0.000653
N15	0.089994	0.010625	0.058819	0.007499	0.000885	0.004902	0.007499	0.000625
N16	0.085847	0.010035	0.059410	0.007154	0.000836	0.004951	0.007154	0.000596
N17	0.081600	0.009444	0.060000	0.006800	0.000787	0.005000	0.006800	0.000567
N18	0.077253	0.008854	0.060590	0.006438	0.000738	0.005049	0.006438	0.000536

Table 3.9: CC Matrix for Model one**APPENDIX E**

	1	2	3	4	5	6	7	8
1	0.080104	0.142968	0.818386	0.133542	0.009780	0.055985	0.008652	0.099443
2	0.142968	0.267140	1.512609	0.259657	0.017564	0.099443	0.016181	0.184912
3	0.818386	1.512609	8.675245	1.486384	0.099443	0.570331	0.092627	1.048988
4	0.133542	0.259657	1.486384	0.270417	0.016181	0.092627	0.016082	0.179266
5	0.009780	0.017564	0.099443	0.016181	0.001206	0.006826	0.001052	0.012200
6	0.055985	0.099443	0.570331	0.092627	0.006826	0.039149	0.006022	0.069208
7	0.008652	0.016181	0.092627	0.016082	0.001052	0.006022	0.000993	0.011208
8	0.099443	0.184912	1.048988	0.179266	0.012200	0.069208	0.011208	0.128067
9	0.016181	0.031658	0.179266	0.032552	0.001979	0.011208	0.001941	0.021827
10	0.092627	0.179266	1.028149	0.186342	0.011208	0.064284	0.011113	0.123831
11	0.006826	0.012201	0.069208	0.011208	0.000840	0.004767	0.000731	0.008480
12	0.001052	0.001979	0.011208	0.001941	0.000129	0.000731	0.000120	0.001369
13	0.006022	0.011208	0.064284	0.011113	0.000731	0.004194	0.000688	0.007768
14	0.011208	0.021827	0.123831	0.022400	0.001369	0.007768	0.001340	0.015057
15	0.000731	0.001369	0.007768	0.001340	0.000090	0.000509	0.000083	0.000948

Table 3.9: CC Matrix for Model one continued

	9	10	11	12	13	14	15
1	0.016181	0.092627	0.006826	0.001052	0.006022	0.011208	0.000731
2	0.031658	0.179266	0.012200	0.001979	0.011208	0.021827	0.001369
3	0.179266	1.028149	0.069208	0.011208	0.064284	0.123831	0.007768
4	0.032552	0.186342	0.011208	0.001941	0.011113	0.022400	0.001340
5	0.001979	0.011208	0.000840	0.000129	0.000731	0.001369	0.000090
6	0.011208	0.064284	0.004767	0.000731	0.004194	0.007768	0.000509
7	0.001941	0.011113	0.000731	0.000120	0.000688	0.001340	0.000083
8	0.021827	0.123831	0.008480	0.001369	0.007768	0.015057	0.000948
9	0.003956	0.022400	0.001369	0.000237	0.001340	0.002718	0.000163
10	0.022400	0.128469	0.007768	0.001340	0.007683	0.015421	0.000925
11	0.001369	0.007768	0.000586	0.000090	0.000509	0.000948	0.000062
12	0.000237	0.001340	0.000090	0.000015	0.000083	0.000163	0.000010
13	0.001340	0.007683	0.000509	0.000083	0.000477	0.000925	0.000058
14	0.002718	0.015421	0.000948	0.000163	0.000925	0.001869	0.000112
15	0.000163	0.000925	0.000062	0.000010	0.000058	0.000112	0.000007

APPENDIX F

Table 3.10: CC Matrix Inverse for Model one

	1	2	3	4	5	6	7
1	-2345361.2942	-1096396.9462	284626.1591	984573.3537	3407865.3832	2091501.0293	-3633159.1354
2	700274.5227	102421.5379	-83513.4642	-110510.8197	-162754.5584	-362073.4530	3266181.7266
3	77425.2316	75757.5806	-33204.0269	-72447.5389	-168920.1792	-10274.9026	218195.6732
4	-128083.4047	39283.6167	40778.0902	-17062.7123	-145547.2646	22282.7029	-3232071.4446
5	-1765507.3972	-338844.0397	412123.3201	515459.4175	2814448.7335	-814665.5192	-7514061.7800
6	2147579.3563	766840.0398	-60705.9799	-664344.2348	-2670249.2755	-2276006.5402	3220329.4610
7	6371974.6898	4082713.6617	-403284.9464	-909874.4200	-16784095.4360	-5860079.7897	-15296196.1671
8	-988510.6515	-382772.3068	62376.6372	369548.9817	1045490.8950	755418.5014	-3232426.6672
9	235153.5914	278163.5428	64858.0566	-197011.6853	-1341156.6335	-860635.5911	-2827870.8080
10	-67147.5965	-266405.4269	71864.8254	205251.3051	724306.3059	32725.0067	4008466.5545
11	5412919.5818	2991444.2473	-444559.8365	-2785112.9548	-14574734.7566	-4620955.8733	-2274853.1230
12	-81622697.1817	-43747834.8973	23887270.8377	33217384.2009	100926333.3430	27573053.9230	-256549893.9817
13	-8876784.0862	-7706677.6998	1103803.7800	4040694.8821	24313602.8971	4337915.3806	-1827016.6356
14	-1000983.3454	-309008.0526	51060.4811	320148.7064	572195.8475	458054.0756	440190.5270
15	133626622.4404	88498865.5635	-40340414.8852	-79187929.1116	-182879085.4031	-23516625.1345	533431090.2160

Table 3.10: CC Matrix Inverse for Model one continued

	8	9	10	11	12	13
1	1299886.6294	-762958.2030	-1439296.6936	-14504393.9526	-129829775.1363	-31598072.4108
2	1305625.9527	2405961.0486	390534.8457	-10003518.6317	52273716.9897	2206725.9218
3	-14236.3708	38603.9730	102669.2839	983807.3629	2542107.5972	3597067.8992
4	-2748493.9559	-2791665.3052	-59131.8793	19871207.8364	-45386302.5818	-1831943.9831
5	-2043831.2353	-4511503.2709	-2193176.7414	13732946.8733	-162722850.7254	-3372595.1822
6	-1226751.4540	1042176.7398	1064027.2986	5561758.2149	162609684.1223	5479105.8140
7	-27756064.4376	-16481015.5553	2207809.4436	208258645.1742	581957314.4891	61520801.8668
8	302912.0378	-2127504.3896	-761941.2602	-3258.4891	-103779582.2599	-1205819.8557
9	-2839852.6165	-1328103.3933	-21875.8704	21638214.8545	3184204.1362	4123244.3760
10	3801350.0024	3876475.7190	-110703.2238	-32180562.3724	73495083.2650	-12989284.1530
11	-18036389.5457	-6786341.0659	4751745.5583	142562850.2278	506478296.4327	44330676.4615
12	-25855659.0105	-131991737.9160	-58841576.7208	-306389726.1979	12783526902.0947	-1824991152.5776
13	26461728.0919	8454557.1379	-8670928.3745	-178128679.8922	-863838690.8279	-77412022.5269
14	1138560.2158	-209995.1727	-888450.6273	-3318640.8634	-97906103.2113	2960851.1675
15	80194399.6631	269864583.6306	142404220.3858	-33114242.6666	-17485029311.1273	2758505165.1188

Table 3.10: CC Matrix Inverse for Model one continued

	14	15
1	-6496609.2517	514630926.6783
2	-9088443.1461	-132790687.3956
3	683837.3578	-37307560.5238
4	14860274.0492	112458622.6133
5	16348335.7868	356604244.0504
6	-735300.9089	-334787371.9596
7	115321134.9052	-1220619724.9326
8	4674212.0968	202275506.1083
9	12360986.2226	-11107001.6801
10	-24263247.2418	-33254469.3288
11	72869997.1055	-1136484249.2567
12	-191751736.0761	597179043.4003
13	-82929043.1923	1997188998.6995
14	-281318.3212	120642474.5344
15	-70253143.1416	-5489050956.2558

APPENDIX G

Table 3.11: Z matrix for the control mixes (Model one)

S/N	Z ₁	Z ₂	Z ₃	Z ₄	Z ₁ Z ₂	Z ₁ Z ₃	Z ₁ Z ₄	Z ₂ Z ₃
C1	0.050000	0.126000	0.674200	0.150000	0.006300	0.033710	0.007500	0.084949
C2	0.050000	0.096900	0.698100	0.155000	0.004845	0.034905	0.007750	0.067646
C3	0.050000	0.106250	0.698750	0.145000	0.005313	0.034938	0.007250	0.074242
C4	0.062500	0.127500	0.685000	0.125000	0.007969	0.042813	0.007813	0.087338
C5	0.062496	0.120055	0.692457	0.124992	0.007503	0.043276	0.007812	0.083133
C6	0.062500	0.106250	0.706250	0.125000	0.006641	0.044141	0.007813	0.075039
C7	0.083333	0.110833	0.722500	0.083333	0.009236	0.060208	0.006944	0.080077
C8	0.083333	0.117500	0.715833	0.083333	0.009792	0.059653	0.006944	0.084110
C9	0.083333	0.107500	0.725833	0.083333	0.008958	0.060486	0.006944	0.078027

Table 3.11: Z matrix for the control mixes (Model one) continued

S/N	Z_2Z_4	Z_3Z_4	$Z_1Z_2Z_3$	$Z_1Z_2Z_4$	$Z_1Z_3Z_4$	$Z_2Z_3Z_4$	$Z_1Z_2Z_3Z_4$
C1	0.018900	0.101130	0.004247	0.000945	0.005057	0.012742	0.000637
C2	0.015020	0.108206	0.003382	0.000751	0.005410	0.010485	0.000524
C3	0.015406	0.101319	0.003712	0.000770	0.005066	0.010765	0.000538
C4	0.015938	0.085625	0.005459	0.000996	0.005352	0.010917	0.000682
C5	0.015006	0.086552	0.005195	0.000938	0.005409	0.010391	0.000649
C6	0.013281	0.088281	0.004690	0.000830	0.005518	0.009380	0.000586
C7	0.009236	0.060208	0.006673	0.000770	0.005017	0.006673	0.000556
C8	0.009792	0.059653	0.007009	0.000816	0.004971	0.007009	0.000584
C9	0.008958	0.060486	0.006502	0.000747	0.005041	0.006502	0.000542

Table 3.12: Z Matrix for Model two**APPENDIX H**

S/N	Z₁	Z₂	Z₃	Z₁Z₂	Z₁Z₃	Z₂Z₃	Z₁Z₂Z₃
N1	0.143158	0.698947	0.157895	0.100060	0.022604	0.110360	0.015799
N2	0.134211	0.707895	0.157895	0.095007	0.021191	0.111773	0.015001
N3	0.129737	0.712368	0.157895	0.092420	0.020485	0.112479	0.014593
N4	0.120789	0.721316	0.157895	0.087127	0.019072	0.113892	0.013757
N5	0.116316	0.725789	0.157895	0.084421	0.018366	0.114598	0.013330
N6	0.107368	0.734737	0.157895	0.078888	0.016953	0.116011	0.012456
N7	0.147333	0.719333	0.133333	0.105982	0.019644	0.095911	0.014131
N8	0.139800	0.726867	0.133333	0.101616	0.018640	0.096916	0.013549
N9	0.132600	0.734067	0.133333	0.097337	0.017680	0.097876	0.012978
N10	0.124667	0.742000	0.133333	0.092503	0.016622	0.098933	0.012334
N11	0.117867	0.748800	0.133333	0.088259	0.015716	0.099840	0.011768
N12	0.110667	0.756000	0.133333	0.083664	0.014756	0.100800	0.011155
N13	0.154545	0.754545	0.090909	0.116612	0.014050	0.068595	0.010601
N14	0.146818	0.762273	0.090909	0.111915	0.013347	0.069298	0.010174
N15	0.139091	0.770000	0.090909	0.107100	0.012645	0.070000	0.009736
N16	0.131364	0.777727	0.090909	0.102165	0.011942	0.070702	0.009288
N17	0.123636	0.785455	0.090909	0.097111	0.011240	0.071405	0.008828
N18	0.115909	0.793182	0.090909	0.091937	0.010537	0.072107	0.008358

Table 3.12: Z Matrix for Model two continued

S/N	Z_1Z_1	Z_2Z_2	Z_3Z_3	$Z_1Z_1Z_2$	$Z_1Z_1Z_3$	$Z_1Z_2Z_2$	$Z_1Z_3Z_3$
N1	0.020494	0.488527	0.024931	0.014324	0.003236	0.069937	0.003569
N2	0.018012	0.501115	0.024931	0.012751	0.002844	0.067255	0.003346
N3	0.016832	0.507469	0.024931	0.011990	0.002658	0.065837	0.003234
N4	0.014590	0.520296	0.024931	0.010524	0.002304	0.062846	0.003011
N5	0.013529	0.526770	0.024931	0.009819	0.002136	0.061272	0.002900
N6	0.011528	0.539838	0.024931	0.008470	0.001820	0.057962	0.002677
N7	0.021707	0.517440	0.017778	0.015615	0.002894	0.076236	0.002619
N8	0.019544	0.528335	0.017778	0.014206	0.002606	0.073861	0.002485
N9	0.017583	0.538854	0.017778	0.012907	0.002344	0.071452	0.002357
N10	0.015542	0.550564	0.017778	0.011532	0.002072	0.068637	0.002216
N11	0.013893	0.560701	0.017778	0.010403	0.001852	0.066088	0.002095
N12	0.012247	0.571536	0.017778	0.009259	0.001633	0.063250	0.001967
N13	0.023884	0.569339	0.008264	0.018022	0.002171	0.087989	0.001277
N14	0.021556	0.581060	0.008264	0.016431	0.001960	0.085310	0.001213
N15	0.019346	0.592900	0.008264	0.014897	0.001759	0.082467	0.001150
N16	0.017256	0.604860	0.008264	0.013421	0.001569	0.079457	0.001086
N17	0.015286	0.616939	0.008264	0.012006	0.001390	0.076276	0.001022
N18	0.013435	0.629137	0.008264	0.010656	0.001221	0.072923	0.000958

Table 3.12: Z Matrix for Model two continued

S/N	$Z_2Z_2Z_3$	$Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2$	$Z_1Z_1Z_3Z_3$	$Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3$	$Z_1Z_1Z_2Z_3Z_3$
N1	0.077136	0.017425	0.010012	0.000511	0.012179	0.001581	0.000357
N2	0.079123	0.017648	0.009026	0.000449	0.012493	0.001425	0.000318
N3	0.080127	0.017760	0.008542	0.000420	0.012652	0.001349	0.000299
N4	0.082152	0.017983	0.007591	0.000364	0.012971	0.001199	0.000262
N5	0.083174	0.018094	0.007127	0.000337	0.013133	0.001125	0.000245
N6	0.085238	0.018318	0.006223	0.000287	0.013459	0.000983	0.000211
N7	0.068992	0.012788	0.011232	0.000386	0.009199	0.001498	0.000278
N8	0.070445	0.012922	0.010326	0.000347	0.009393	0.001377	0.000253
N9	0.071847	0.013050	0.009475	0.000313	0.009580	0.001263	0.000229
N10	0.073409	0.013191	0.008557	0.000276	0.009788	0.001141	0.000205
N11	0.074760	0.013312	0.007790	0.000247	0.009968	0.001039	0.000185
N12	0.076205	0.013440	0.007000	0.000218	0.010161	0.000933	0.000165
N13	0.051758	0.006236	0.013598	0.000197	0.004705	0.001236	0.000149
N14	0.052824	0.006300	0.012525	0.000178	0.004802	0.001139	0.000136
N15	0.053900	0.006364	0.011470	0.000160	0.004900	0.001043	0.000123
N16	0.054987	0.006427	0.010438	0.000143	0.004999	0.000949	0.000111
N17	0.056085	0.006491	0.009430	0.000126	0.005099	0.000857	0.000099
N18	0.057194	0.006555	0.008452	0.000111	0.005199	0.000768	0.000088

Table 3.12: Z Matrix for Model two continued

S/N	$Z_1Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3Z_3$
N1	0.001744	0.000250
N2	0.001677	0.000225
N3	0.001641	0.000213
N4	0.001567	0.000189
N5	0.001528	0.000178
N6	0.001445	0.000155
N7	0.001355	0.000200
N8	0.001313	0.000184
N9	0.001270	0.000168
N10	0.001220	0.000152
N11	0.001175	0.000138
N12	0.001124	0.000124
N13	0.000727	0.000112
N14	0.000705	0.000104
N15	0.000682	0.000095
N16	0.000657	0.000086
N17	0.000630	0.000078
N18	0.000603	0.000070

Table 3.13: CC Matrix for Model two

	1	2	3	4	5	6	7
1	0.306265	1.734123	0.295488	0.227233	0.038469	0.217835	0.028341
2	1.734123	9.945682	1.691497	1.289054	0.217835	1.249356	0.160781
3	0.295488	1.691497	0.305838	0.217835	0.039184	0.224305	0.028713
4	0.227233	1.289054	0.217835	0.168814	0.028341	0.160781	0.020904
5	0.038469	0.217835	0.039184	0.028341	0.005070	0.028713	0.003712
6	0.217835	1.249356	0.224305	0.160781	0.028713	0.164679	0.021063
7	0.028341	0.160782	0.028713	0.020904	0.003712	0.021063	0.002721
8	0.040562	0.227233	0.038469	0.030079	0.005058	0.028341	0.003724
9	1.289054	7.407271	1.249356	0.959459	0.160781	0.923896	0.118815
10	0.039184	0.224305	0.042349	0.028713	0.005400	0.030913	0.003938
11	0.030079	0.168814	0.028341	0.022334	0.003724	0.020904	0.002745
12	0.005058	0.028341	0.005070	0.003724	0.000663	0.003712	0.000485
13	0.168814	0.959459	0.160782	0.125576	0.020904	0.118815	0.015437
14	0.005070	0.028713	0.005400	0.003712	0.000695	0.003938	0.000507
15	0.160782	0.923896	0.164679	0.118815	0.021063	0.121031	0.015467
16	0.028713	0.164679	0.030913	0.021063	0.003938	0.022585	0.002874
17	0.022334	0.125576	0.020904	0.016605	0.002745	0.015437	0.002026
18	0.000663	0.003712	0.000695	0.000485	0.000090	0.000507	0.000066
19	0.021063	0.121031	0.022585	0.015467	0.002874	0.016516	0.002100
20	0.002745	0.015437	0.002721	0.002026	0.000355	0.001997	0.000260
21	0.000485	0.002721	0.000507	0.000355	0.000066	0.000369	0.000048
22	0.002721	0.015467	0.002874	0.001997	0.000369	0.002100	0.000270
23	0.000355	0.001997	0.000369	0.000260	0.000048	0.000270	0.000035

Table 3.13: CC Matrix for Model two continued

	8	9	10	11	12	13	14
1	0.040562	1.289054	0.039184	0.030079	0.005058	0.168814	0.005070
2	0.227233	7.407271	0.224305	0.168814	0.028341	0.959459	0.028713
3	0.038469	1.249356	0.042349	0.028341	0.005070	0.160781	0.005400
4	0.030079	0.959459	0.028713	0.022334	0.003724	0.125576	0.003712
5	0.005058	0.160781	0.005400	0.003724	0.000663	0.020904	0.000695
6	0.028341	0.923896	0.030913	0.020904	0.003712	0.118815	0.003938
7	0.003724	0.118815	0.003938	0.002745	0.000485	0.015438	0.000507
8	0.005425	0.168814	0.005070	0.004021	0.000672	0.022334	0.000663
9	0.168814	5.523917	0.164679	0.125576	0.020904	0.715068	0.021063
10	0.005070	0.164679	0.006035	0.003712	0.000695	0.021063	0.000767
11	0.004021	0.125576	0.003712	0.002984	0.000494	0.016605	0.000485
12	0.000672	0.020904	0.000695	0.000494	0.000087	0.002745	0.000090
13	0.022334	0.715068	0.021063	0.016605	0.002745	0.093534	0.002721
14	0.000663	0.021063	0.000767	0.000485	0.000090	0.002721	0.000098
15	0.020904	0.684050	0.022585	0.015437	0.002721	0.087910	0.002874
16	0.003712	0.121031	0.004390	0.002721	0.000507	0.015467	0.000557
17	0.002984	0.093534	0.002721	0.002218	0.000364	0.012361	0.000355
18	0.000087	0.002721	0.000098	0.000064	0.000012	0.000355	0.000013
19	0.002721	0.089047	0.003195	0.001997	0.000369	0.011371	0.000405
20	0.000364	0.011415	0.000369	0.000269	0.000047	0.001497	0.000048
21	0.000064	0.001997	0.000071	0.000047	0.000009	0.000260	0.000009
22	0.000355	0.011371	0.000405	0.000260	0.000048	0.001467	0.000052
23	0.000047	0.001467	0.000052	0.000034	0.000006	0.000191	0.000007

Table 3.13: CC Matrix for Model two continued

	15	16	17	18	19	20	21
1	0.160781	0.028713	0.022334	0.000663	0.021063	0.002745	0.000485
2	0.923896	0.164679	0.125576	0.003712	0.121031	0.015437	0.002721
3	0.164679	0.030913	0.020904	0.000695	0.022585	0.002721	0.000507
4	0.118815	0.021063	0.016604	0.000485	0.015467	0.002026	0.000355
5	0.021063	0.003938	0.002745	0.000090	0.002874	0.000355	0.000066
6	0.121031	0.022585	0.015437	0.000507	0.016516	0.001997	0.000369
7	0.015467	0.002874	0.002026	0.000066	0.002100	0.000260	0.000048
8	0.020904	0.003712	0.002984	0.000087	0.002721	0.000364	0.000064
9	0.684050	0.121031	0.093534	0.002721	0.089047	0.011415	0.001997
10	0.022585	0.004390	0.002721	0.000098	0.003195	0.000369	0.000071
11	0.015438	0.002721	0.002218	0.000064	0.001997	0.000269	0.000047
12	0.002721	0.000507	0.000364	0.000012	0.000369	0.000047	0.000009
13	0.087910	0.015467	0.012361	0.000355	0.011371	0.001497	0.000260
14	0.002874	0.000557	0.000355	0.000013	0.000405	0.000048	0.000009
15	0.089047	0.016516	0.011415	0.000369	0.012089	0.001467	0.000270
16	0.016516	0.003195	0.001997	0.000071	0.002327	0.000270	0.000052
17	0.011415	0.001997	0.001650	0.000047	0.001467	0.000198	0.000034
18	0.000369	0.000071	0.000047	0.000002	0.000052	0.000006	0.000001
19	0.012089	0.002327	0.001467	0.000052	0.001697	0.000197	0.000038
20	0.001467	0.000270	0.000198	0.000006	0.000197	0.000025	0.000005
21	0.000270	0.000052	0.000034	0.000001	0.000038	0.000005	0.000001
22	0.001536	0.000295	0.000191	0.000007	0.000215	0.000026	0.000005
23	0.000197	0.000038	0.000025	0.000001	0.000027	0.000003	0.000001

Table 3.13: CC Matrix for Model two continued

	22	23
1	0.002721	0.000355
2	0.015467	0.001997
3	0.002874	0.000369
4	0.001997	0.000260
5	0.000369	0.000048
6	0.002100	0.000270
7	0.000270	0.000035
8	0.000355	0.000047
9	0.011371	0.001467
10	0.000405	0.000052
11	0.000260	0.000034
12	0.000048	0.000006
13	0.001467	0.000191
14	0.000052	0.000007
15	0.001536	0.000197
16	0.000295	0.000038
17	0.000191	0.000025
18	0.000007	0.000001
19	0.000215	0.000027
20	0.000026	0.000003
21	0.000005	0.000001
22	0.000027	0.000004
23	0.000004	0.000000

Table 3.14: CC Matrix Inverse for Model two**APPENDIX J**

	1	2	3	4	5	6	7
1	17960.4707	-31330.6008	-58485.3837	108791.5085	22858.7652	-197636.7133	-59209.1206
2	8561.5483	19008.9118	-4479.6335	-2272.4095	-47745.7546	81591.1505	844990.0746
3	-18417.0304	179479.2384	103464.9274	-127251.1287	-78706.8851	551915.0873	11091832.9706
4	-14613.6863	-109739.4090	-66594.4891	151736.3960	639.8476	-225586.0173	-3133275.1275
5	-15747.7553	-109424.4711	-23995.9542	-8728.9360	-1311614.4128	-1737652.2619	4008643.2331
6	-58831.1511	-28539.8361	91261.4815	-53437.7740	-148091.8493	154468.9721	-9305152.0970
7	324210.7699	-884753.3228	-1152477.6917	883423.8776	-2545877.4427	4613264.2632	-32275586.5793
8	-16569.0451	-127458.0023	-147348.7852	167720.2444	-340337.2961	271063.1314	10544881.0325
9	-5921.4716	-23357.2889	2869.8665	-3903.0498	93255.3193	-153209.0919	-890153.2391
10	11462.8007	-299569.1419	-310425.4670	491438.4668	-5962519.5748	6481941.5949	-10856882.8404
11	89999.9291	191211.7105	-43991.6346	294352.6123	-2749116.8615	4042929.2115	-17468110.2964
12	-695162.1519	-103430.4924	-1723854.1534	1046624.9316	-7553641.1507	8465191.1037	-46446555.1688
13	-24322.8915	243281.4880	153099.5814	-219536.2695	-359172.1850	1050169.7650	5861364.1003
14	-1151091.5826	-563808.9477	-235091.1836	-1554694.8074	-676193.2688	2788120.1383	17069436.7696
15	13137.4647	-191663.9828	-146314.4727	246334.0856	-98598.1615	-236406.4625	-4612099.5123
16	-187041.0492	103501.4362	309040.1592	448627.3416	7580805.5218	-7716196.1277	-12407373.4668
17	-70460.6102	-417870.2838	587372.0679	-1317308.3678	6757825.1773	-9092347.3574	-11048544.5759
18	1261431.3881	-7225278.6760	-5997820.6654	3333092.7156	-62219787.3748	65923543.5744	-1136456795.6396
19	579850.6181	455829.3550	-77451.0032	-1472213.1634	2029562.3388	-3504912.6295	34230713.9116
20	-668188.6946	5983077.0314	5316109.3636	-5845752.7077	9456908.1324	1592590.0611	205408204.6552
21	12862802.5408	14064606.0134	-3438574.7349	28381489.3972	201787722.127	-220665899.6357	2283326670.1520
22	438983.8719	-3762002.8627	-2365988.1099	3308134.7681	22465555.3308	-42525867.2507	-212028137.7203
23	-7199963.1602	19632045.9119	68793829.7785	-85983086.8816	75445413.3188	-7239160.1425	-318254798.1609

Table 3.14: CC Matrix Inverse for Model two continued

	8	9	10	11	12	13
1	-1278619.4487	67883.4940	-5232189.3771	2475222.1860	-8595376.2459	-673871.4483
2	-796911.2256	17305.1981	1827833.9199	624753.6747	-1661141.8116	-978280.9285
3	-3194328.4464	-206406.4314	24540227.9520	2497328.7517	-27287806.1173	-2370379.3692
4	-170527.8399	-40655.3375	-12792465.7939	1056441.5936	27456793.1529	3459204.3391
5	4840607.1678	62897.6210	-12194100.2417	-10325031.3410	29484279.8528	3210997.8516
6	7048803.1153	-139018.2648	-13168977.5559	-14583165.4652	21880725.3523	4356230.7202
7	-52452854.4776	363847.1171	-20943955.8417	76148244.0023	-3882389.2788	7124713.1779
8	8585888.7751	-92860.5779	-4713170.0129	-7281057.7614	15318085.5642	4081468.1249
9	1128649.7739	12616.3665	-1443401.7478	-797.4635	319845.2588	674358.0699
10	-62449211.9178	-946785.9470	-40570651.8950	55840683.1365	81404346.9944	16151707.4185
11	-46621695.5346	-150191.5807	13782586.1931	67372385.3126	-21718572.0974	-7740849.9080
12	-91031474.3363	-1446753.5521	-73453032.5121	129481129.2301	63054979.9632	25485518.0769
13	292828.3774	-363050.7134	17614315.7958	-14546303.2114	-5281833.8200	-202956.4146
14	-26524998.0926	1746894.3504	62322685.3473	11605077.1074	-46630380.7501	-26903067.3918
15	-6360691.6683	133455.4085	-21246064.4498	12045437.2958	17719920.7639	2283724.7520
16	74205692.1246	1086662.6146	6958112.8032	-71805792.2044	-64214835.8568	-7042597.3953
17	74313752.0767	1578233.8842	-11972303.6757	-59221323.4055	-36915898.1061	-1555845.6925
18	-123330876.9073	-34170081.5713	-2011349553.1743	-451887092.5768	3796045540.6105	701893770.1855
19	23308560.3853	968193.1519	59926278.4841	-47597801.6235	-18357398.5135	-28344473.8906
20	65387358.3013	-3622997.6402	626125953.0244	-240953811.0025	-253673575.8180	-100831274.6964
21	526828493.7894	37965162.7427	4935738039.7338	1364055789.8885	-10041016832.4252	-1299692670.2621
22	265366980.5760	6991476.0371	-495505083.7321	587556166.1208	-211829111.8878	16768721.0987
23	2193561180.1555	35790177.3893	-2480280744.5797	-6841145380.4071	7370046681.2242	35662421.1488

Table 3.14: CC Matrix Inverse for Model two continued

	14	15	16	17	18	19
1	16405109.6734	371498.3761	12165404.9891	2178039.7602	-281119128.0345	-6135579.8024
2	15453880.9287	376596.9633	-1183744.0184	3785152.6745	-62649316.5778	-6109178.3690
3	-10690015.9333	1649486.2471	-36779592.3828	11542933.2613	354691766.7586	-9691090.9307
4	-4402931.7250	-832675.6863	20381105.2920	-13967031.2535	-112932332.0212	11819220.4026
5	-14114278.0637	-1465215.7592	1484979.1910	-8444034.0826	257705797.6315	39704574.9152
6	-11596937.4848	-1823418.3564	11812391.3594	-7312166.9526	60680106.0641	23442558.2712
7	50794574.9974	-513357.6411	88037427.3108	-54059950.2580	-299262683.4817	-37414121.5263
8	14753254.8512	-1098127.4455	5897682.5353	-20647536.1388	-29439290.6325	15671263.6422
9	-15422058.6282	-320249.0991	953731.1020	-4070628.6622	39832376.1463	4663341.6574
10	55572538.9903	-3321693.3847	155717457.5930	-47683615.7358	-508497420.5426	-53358319.5590
11	10032034.8626	4429800.9416	36520221.8713	18902394.4202	-510380281.1954	-112113444.2250
12	120755407.5333	-6922100.5662	227241987.5328	-142364141.6922	-1071544661.1461	-37506420.8630
13	-32818317.2199	-131276.9645	-35427383.4151	19134700.1175	708449537.8830	7695159.9086
14	-15106305.7477	10726457.8724	-64816789.5782	164808326.8070	112583446.3577	-159756339.1775
15	13450552.8438	-1031834.4442	36351865.5612	-15093128.2715	-291597216.5305	6051416.5731
16	-53471281.8808	-4373289.6476	-123805042.3255	-5240887.0315	537747090.7748	135391956.9118
17	-61191368.8915	-6257892.7908	-115422345.0252	-31659684.4158	655909946.0224	175862987.1540
18	-1905985581.3938	-95659242.6545	4185354067.3031	-1957932495.1093	54718456817.2321	303287560.0215
19	-80361059.9874	9459744.4025	-121479898.6125	153957424.7482	313317957.7023	-76543583.3826
20	-866185269.4398	65698123.9514	-319928738.4747	499857628.2947	6883969443.8707	-1279999607.3686
21	4675926411.5225	710123179.0118	-9101391122.1794	2890632835.0709	-116478147770.3300	-2363544823.7830
22	642783060.0337	30835455.1724	1152656301.1164	-1194186394.0143	-22410947656.1093	-779059108.6024
23	-6109839837.2609	-1275867492.6218	-5191963809.6851	5169791491.7092	123391088268.6750	14074023777.325

Table 3.14: CC Matrix Inverse for Model two continued

	20	21	22	23
1	-16332087.1642	416600372.5792	-52746496.0459	277283553.7652
2	6226141.6836	4810148.1945	5472919.9330	-95948980.3643
3	924667.1334	-568281308.8042	27865032.6897	-248407420.0019
4	-42301982.0049	165740008.4520	-139758047.8156	700638055.8879
5	-3003208.0636	-105511562.4767	-14724462.6038	-325863773.2584
6	-24234357.2436	-262357554.6781	-83685762.3530	996773751.3899
7	452997430.3363	984806885.9436	-754182351.6801	1155523264.4390
8	-76858681.9830	-140285166.6009	-225779651.3639	765327410.9545
9	-4147015.2025	18781402.8192	12839283.7032	34913245.6128
10	321664298.0786	1503164673.4073	-1579032438.6251	3206008428.1415
11	113014727.2271	1256765241.9630	3285687.9045	-622140035.0469
12	738023972.2186	2581994485.1739	-2145830420.3549	4402471465.0520
13	17251361.1375	-928719443.3963	65328986.2446	-437743293.3319
14	-199715532.6569	-775921889.0261	1185008663.4916	-2758216045.8047
15	11885841.9061	870025659.0216	-142401660.4465	-77511015.1827
16	22684231.2177	-1464063975.7698	1287091569.9528	-2819909406.0667
17	-15548049.6213	-1316434505.2152	1297272093.7342	-3079831987.8817
18	2949454911.1049	-89597889735.3977	-22422628092.2486	111168136873.9320
19	-534360183.7293	-862417301.1551	1681338214.0887	-4159762007.8449
20	1324178195.4968	-11837686251.9110	4492684908.7532	-27547672705.5539
21	-13065216240.3176	257350447792.7110	38865590726.0231	-285906122375.1970
22	-1580280071.5604	32797206421.9447	3396613676.5324	-9113317624.9328
23	-8416602931.8062	-316458094288.5250	40976968061.2150	158184143418.9230

Table 3.15: Z matrix for the control mixes (Model two)**APPENDIX K**

S/N	Z₁	Z₂	Z₃	Z₁Z₂	Z₁Z₃	Z₂Z₃	Z₁Z₂Z₃
C1	0.13260366	0.70953483	0.15786150	0.09408692	0.02093301	0.11200824	0.01485270
C2	0.10200000	0.73484211	0.16315789	0.07495389	0.01664211	0.11989529	0.01222932
C3	0.11184211	0.73552632	0.15263158	0.08226281	0.01707064	0.11226454	0.01255590
C4	0.13600000	0.73066667	0.13333333	0.09937067	0.01813333	0.09742222	0.01324942
C5	0.12805813	0.73861743	0.13332445	0.09458597	0.01707328	0.09847576	0.01261062
C6	0.11333333	0.75333333	0.13333333	0.08537778	0.01511111	0.10044444	0.01138370
C7	0.12090909	0.78818182	0.09090909	0.09529835	0.01099174	0.07165289	0.00866349
C8	0.12818182	0.78090909	0.09090909	0.10009835	0.01165289	0.07099174	0.00909985
C9	0.11727273	0.79181818	0.09090909	0.09285868	0.01066116	0.07198347	0.00844170

Table 3.15: Z matrix for the control mixes (Model two) continued

S/N	Z_1Z_1	Z_2Z_2	Z_3Z_3	$Z_1Z_1Z_2$	$Z_1Z_1Z_3$	$Z_1Z_2Z_2$	$Z_1Z_3Z_3$
C1	0.01758373	0.50343968	0.02492025	0.01247627	0.00277579	0.06675795	0.00330452
C2	0.01040400	0.53999292	0.02662050	0.00764530	0.00169749	0.05507928	0.00271529
C3	0.01250866	0.54099896	0.02329640	0.00920045	0.00190922	0.06050646	0.00260552
C4	0.01849600	0.53387378	0.01777778	0.01351441	0.00246613	0.07260683	0.00241778
C5	0.01639888	0.54555570	0.01777541	0.01211250	0.00218637	0.06986284	0.00227629
C6	0.01284444	0.56751111	0.01777778	0.00967615	0.00171259	0.06431793	0.00201481
C7	0.01461901	0.62123058	0.00826446	0.01152244	0.00132900	0.07511242	0.00099925
C8	0.01643058	0.60981901	0.00826446	0.01283079	0.00149369	0.07816771	0.00105935
C9	0.01375289	0.62697603	0.00826446	0.01088979	0.00125026	0.07352719	0.00096920

Table 3.15: Z matrix for the control mixes (Model two) continued

S/N	$Z_2Z_2Z_3$	$Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2$	$Z_1Z_1Z_3Z_3$	$Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3$	$Z_1Z_1Z_2Z_3Z_3$
C1	0.07947374	0.01768179	0.00885235	0.00043819	0.01254584	0.00139744	0.00031091
C2	0.08810411	0.01956186	0.00561809	0.00027696	0.01437488	0.00091664	0.00020352
C3	0.08257353	0.01713511	0.00676717	0.00029141	0.01260333	0.00103288	0.00021434
C4	0.07118317	0.01298963	0.00987453	0.00032882	0.00949109	0.00131660	0.00024026
C5	0.07273591	0.01312923	0.00894650	0.00029150	0.00969747	0.00119279	0.00021530
C6	0.07566815	0.01339259	0.00728936	0.00022835	0.01008909	0.00097192	0.00017202
C7	0.05647551	0.00651390	0.00908177	0.00012082	0.00513414	0.00082562	0.00009523
C8	0.05543809	0.00645379	0.01001968	0.00013579	0.00503983	0.00091088	0.00010604
C9	0.05699782	0.00654395	0.00862273	0.00011366	0.00518162	0.00078388	0.00009000

Table 3.15: Z matrix for the control mixes (Model two) continued

S/N	$Z_1Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3Z_3$
C1	0.00166362	0.00022060
C2	0.00146624	0.00014956
C3	0.00140958	0.00015765
C4	0.00129079	0.00017555
C5	0.00124184	0.00015903
C6	0.00114343	0.00012959
C7	0.00062076	0.00007506
C8	0.00064601	0.00008281
C9	0.00060766	0.00007126

Table 3.16: Z matrix for Model three**APPENDIX L**

S/N	Z₁	Z₂	Z₃	Z₁Z₂	Z₁Z₃	Z₂Z₃	Z₁Z₂Z₃
N1	0.14315789	0.69894737	0.15789474	0.10005983	0.02260388	0.11036011	0.01579892
N2	0.13421053	0.70789474	0.15789474	0.09500693	0.02119114	0.11177285	0.01500109
N3	0.12973684	0.71236842	0.15789474	0.09242043	0.02048476	0.11247922	0.01459270
N4	0.12078947	0.72131579	0.15789474	0.08712735	0.01907202	0.11389197	0.01375695
N5	0.11631579	0.72578947	0.15789474	0.08442078	0.01836565	0.11459834	0.01332960
N6	0.10736842	0.73473684	0.15789474	0.07888753	0.01695291	0.11601108	0.01245593
N7	0.14733333	0.71933333	0.13333333	0.10598178	0.01964444	0.09591111	0.01413090
N8	0.13980000	0.72686667	0.13333333	0.10161596	0.01864000	0.09691556	0.01354879
N9	0.13260000	0.73406667	0.13333333	0.09733724	0.01768000	0.09787556	0.01297830
N10	0.12466667	0.74200000	0.13333333	0.09250267	0.01662222	0.09893333	0.01233369
N11	0.11786667	0.74880000	0.13333333	0.08825856	0.01571556	0.09984000	0.01176781
N12	0.11066667	0.75600000	0.13333333	0.08366400	0.01475556	0.10080000	0.01115520
N13	0.15454545	0.75454545	0.09090909	0.11661157	0.01404959	0.06859504	0.01060105
N14	0.14681818	0.76227273	0.09090909	0.11191550	0.01334711	0.06929752	0.01017414
N15	0.13909091	0.77000000	0.09090909	0.10710000	0.01264463	0.07000000	0.00973636
N16	0.13136364	0.77772727	0.09090909	0.10216508	0.01194215	0.07070248	0.00928773
N17	0.12363636	0.78545455	0.09090909	0.09711074	0.01123967	0.07140496	0.00882825
N18	0.11590909	0.79318182	0.09090909	0.09193698	0.01053719	0.07210744	0.00835791

Table 3.16: Z matrix for Model three continued

S/N	Z_1Z_1	Z_2Z_2	Z_3Z_3	$Z_1Z_1Z_2$	$Z_1Z_1Z_3$	$Z_1Z_2Z_2$	$Z_1Z_3Z_3$
N1	0.02049418	0.48852742	0.02493075	0.01432436	0.00323592	0.06993656	0.00356903
N2	0.01801247	0.50111496	0.02493075	0.01275093	0.00284407	0.06725490	0.00334597
N3	0.01683165	0.50746877	0.02493075	0.01199033	0.00265763	0.06583740	0.00323444
N4	0.01459010	0.52029647	0.02493075	0.01052407	0.00230370	0.06284634	0.00301137
N5	0.01352936	0.52677036	0.02493075	0.00981947	0.00213622	0.06127171	0.00289984
N6	0.01152798	0.53983823	0.02493075	0.00847003	0.00182021	0.05796158	0.00267678
N7	0.02170711	0.51744044	0.01777778	0.01561465	0.00289428	0.07623623	0.00261926
N8	0.01954404	0.52833515	0.01777778	0.01420591	0.00260587	0.07386125	0.00248533
N9	0.01758276	0.53885387	0.01777778	0.01290692	0.00234437	0.07145202	0.00235733
N10	0.01554178	0.55056400	0.01777778	0.01153200	0.00207224	0.06863698	0.00221630
N11	0.01389255	0.56070144	0.01777778	0.01040274	0.00185234	0.06608801	0.00209541
N12	0.01224711	0.57153600	0.01777778	0.00925882	0.00163295	0.06324998	0.00196741
N13	0.02388430	0.56933884	0.00826446	0.01802179	0.00217130	0.08798873	0.00127724
N14	0.02155558	0.58105971	0.00826446	0.01643123	0.00195960	0.08531013	0.00121337
N15	0.01934628	0.59290000	0.00826446	0.01489664	0.00175875	0.08246700	0.00114951
N16	0.01725640	0.60485971	0.00826446	0.01342078	0.00156876	0.07945657	0.00108565
N17	0.01528595	0.61693884	0.00826446	0.01200642	0.00138963	0.07627608	0.00102179
N18	0.01343492	0.62913740	0.00826446	0.01065633	0.00122136	0.07292274	0.00095793

Table 3.16: Z matrix for Model three continued

S/N	$Z_2Z_2Z_3$	$Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2$	$Z_1Z_1Z_2Z_3$	$Z_1Z_1Z_3Z_3$	$Z_1Z_2Z_2Z_3$	$Z_1Z_2Z_3Z_3$
N1	0.07713591	0.01742528	0.01001197	0.00226174	0.00051094	0.01104261	0.00249457
N2	0.07912341	0.01764835	0.00902632	0.00201330	0.00044906	0.01061920	0.00236859
N3	0.08012665	0.01775988	0.00854154	0.00189321	0.00041963	0.01039538	0.00230411
N4	0.08215207	0.01798294	0.00759118	0.00166169	0.00036374	0.00992311	0.00217215
N5	0.08317427	0.01809447	0.00712687	0.00155044	0.00033730	0.00967448	0.00210467
N6	0.08523761	0.01831754	0.00622324	0.00133737	0.00028740	0.00915183	0.00196673
N7	0.06899206	0.01278815	0.01123214	0.00208195	0.00038590	0.01016483	0.00188412
N8	0.07044469	0.01292207	0.01032580	0.00189412	0.00034745	0.00984817	0.00180651
N9	0.07184718	0.01305007	0.00947454	0.00172092	0.00031258	0.00952694	0.00173044
N10	0.07340853	0.01319111	0.00855674	0.00153760	0.00027630	0.00915160	0.00164449
N11	0.07476019	0.01331200	0.00778957	0.00138703	0.00024698	0.00881173	0.00156904
N12	0.07620480	0.01344000	0.00699966	0.00123451	0.00021773	0.00843333	0.00148736
N13	0.05175808	0.00623591	0.01359826	0.00163834	0.00019739	0.00799898	0.00096373
N14	0.05282361	0.00629977	0.01252508	0.00149375	0.00017815	0.00775547	0.00092492
N15	0.05390000	0.00636364	0.01147041	0.00135424	0.00015989	0.00749700	0.00088512
N16	0.05498725	0.00642750	0.01043770	0.00122007	0.00014261	0.00722332	0.00084434
N17	0.05608535	0.00649136	0.00943050	0.00109149	0.00012633	0.00693419	0.00080257
N18	0.05719431	0.00655522	0.00845241	0.00096876	0.00011103	0.00662934	0.00075981

Table 3.16: Z matrix for Model three continued

S/N	$Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3$	$Z_1Z_1Z_2Z_3Z_3$	$Z_1Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3Z_3$
N1	0.01217935	0.00158084	0.00035712	0.00174357	0.00024961
N2	0.01249317	0.00142521	0.00031789	0.00167672	0.00022503
N3	0.01265158	0.00134866	0.00029893	0.00164138	0.00021295
N4	0.01297138	0.00119861	0.00026237	0.00156681	0.00018925
N5	0.01313278	0.00112529	0.00024481	0.00152755	0.00017768
N6	0.01345857	0.00098262	0.00021116	0.00144503	0.00015515
N7	0.00919894	0.00149762	0.00027759	0.00135531	0.00019968
N8	0.00939262	0.00137677	0.00025255	0.00131309	0.00018357
N9	0.00957962	0.00126327	0.00022946	0.00127026	0.00016844
N10	0.00978780	0.00114090	0.00020501	0.00122021	0.00015212
N11	0.00996803	0.00103861	0.00018494	0.00117490	0.00013848
N12	0.01016064	0.00093329	0.00016460	0.00112444	0.00012444
N13	0.00470528	0.00123621	0.00014894	0.00072718	0.00011238
N14	0.00480215	0.00113864	0.00013580	0.00070504	0.00010351
N15	0.00490000	0.00104276	0.00012311	0.00068155	0.00009480
N16	0.00499884	0.00094888	0.00011092	0.00065667	0.00008626
N17	0.00509867	0.00085732	0.00009923	0.00063038	0.00007794
N18	0.00519948	0.00076840	0.00008807	0.00060267	0.00006985

Table 3.17: CC matrix for Model three

APPENDIX M

	1	2	3	4	5	6	7
1	0.30626500	1.73412300	0.29548800	0.22723300	0.03846900	0.21783500	0.02834100
2	1.73412300	9.94568200	1.69149700	1.28905400	0.21783500	1.24935600	0.16078100
3	0.29548800	1.69149700	0.30583800	0.21783500	0.03918400	0.22430500	0.02871300
4	0.22723300	1.28905400	0.21783500	0.16881400	0.02834100	0.16078100	0.02090400
5	0.03846900	0.21783500	0.03918400	0.02834100	0.00507000	0.02871300	0.00371249
6	0.21783500	1.24935600	0.22430500	0.16078100	0.02871300	0.16467900	0.02106274
7	0.02834060	0.16078150	0.02871330	0.02090390	0.00371249	0.02106270	0.00272114
8	0.04056190	0.22723340	0.03846920	0.03007890	0.00505824	0.02834060	0.00372416
9	1.28905420	7.40727140	1.24935600	0.95945880	0.16078149	0.92389560	0.11881485
10	0.03918390	0.22430530	0.04234870	0.02871330	0.00540027	0.03091310	0.00393805
11	0.03007890	0.16881390	0.02834060	0.02233390	0.00372416	0.02090390	0.00274527
12	0.00505820	0.02834060	0.00507040	0.00372420	0.00066253	0.00371249	0.00048474
13	0.16881390	0.95945880	0.16078150	0.12557610	0.02090390	0.11881485	0.01543750
14	0.00507040	0.02871330	0.00540027	0.00371249	0.00069538	0.00393805	0.00050661
15	0.16078150	0.92389560	0.16467891	0.11881485	0.02106274	0.12103072	0.01546726
16	0.02871330	0.16467890	0.03091309	0.02106274	0.00393805	0.02258545	0.00287434
17	0.02233390	0.12557610	0.02090390	0.01660450	0.00274527	0.01543750	0.00202615
18	0.00372420	0.02090390	0.00371249	0.00274527	0.00048474	0.00272114	0.00035504
19	0.00066253	0.00371249	0.00069538	0.00048474	0.00009040	0.00050661	0.00006580
20	0.02090390	0.11881485	0.02106274	0.01543750	0.00272114	0.01546726	0.00199669
21	0.00371249	0.02106274	0.00393805	0.00272114	0.00050661	0.00287434	0.00036942
22	0.02106274	0.12103072	0.02258545	0.01546726	0.00287434	0.01651611	0.00209988
23	0.00274527	0.01543750	0.00272114	0.00202615	0.00035504	0.00199669	0.00026033
24	0.00048474	0.00272114	0.00050661	0.00035504	0.00006580	0.00036942	0.00004794
25	0.00272114	0.01546726	0.00287434	0.00199669	0.00036942	0.00209988	0.00026963
26	0.00035504	0.00199669	0.00036942	0.00026033	0.00004794	0.00026963	0.00003496

Table 3.17: CC matrix for Model three continued

	8	9	10	11	12	13	14
1	0.04056200	1.28905400	0.03918400	0.03007900	0.00505800	0.16881400	0.00507000
2	0.22723300	7.40727100	0.22430500	0.16881400	0.02834100	0.95945900	0.02871300
3	0.03846900	1.24935600	0.04234900	0.02834100	0.00507000	0.16078100	0.00540027
4	0.03007900	0.95945900	0.02871300	0.02233400	0.00372400	0.12557600	0.00371249
5	0.00505800	0.16078100	0.00540027	0.00372400	0.00066253	0.02090400	0.00069538
6	0.02834100	0.92389600	0.03091309	0.02090400	0.00371249	0.11881500	0.00393805
7	0.00372420	0.11881490	0.00393805	0.00274527	0.00048474	0.01543750	0.00050661
8	0.00542480	0.16881390	0.00507041	0.00402088	0.00067154	0.02233390	0.00066253
9	0.16881390	5.52391710	0.16467891	0.12557614	0.02090390	0.71506780	0.02106274
10	0.00507040	0.16467890	0.00603536	0.00371249	0.00069538	0.02106270	0.00076684
11	0.00402088	0.12557610	0.00371249	0.00298411	0.00049416	0.01660450	0.00048474
12	0.00067154	0.02090390	0.00069538	0.00049416	0.00008739	0.00274527	0.00009040
13	0.02233388	0.71506780	0.02106274	0.01660450	0.00274527	0.09353415	0.00272114
14	0.00066253	0.02106270	0.00076684	0.00048474	0.00009040	0.00272114	0.00009837
15	0.02090390	0.68405000	0.02258545	0.01543750	0.00272114	0.08791010	0.00287434
16	0.00371249	0.12103070	0.00438959	0.00272114	0.00050661	0.01546726	0.00055710
17	0.00298411	0.09353410	0.00272114	0.00221750	0.00036408	0.01236084	0.00035504
18	0.00049416	0.01543750	0.00050661	0.00036408	0.00006390	0.00202615	0.00006580
19	0.00008739	0.00272114	0.00009837	0.00006390	0.00001186	0.00035504	0.00001274
20	0.00274527	0.08791010	0.00287434	0.00202615	0.00035504	0.01141466	0.00036942
21	0.00048474	0.01546726	0.00055710	0.00035504	0.00006580	0.00199669	0.00007139
22	0.00272114	0.08904736	0.00319501	0.00199669	0.00036942	0.01137070	0.00040504
23	0.00036408	0.01141466	0.00036942	0.00026856	0.00004677	0.00149726	0.00004794
24	0.00006390	0.00199669	0.00007139	0.00004677	0.00000863	0.00026033	0.00000923
25	0.00035504	0.01137070	0.00040504	0.00026033	0.00004794	0.00146673	0.00005185
26	0.00004677	0.00146673	0.00005185	0.00003427	0.00000628	0.00019109	0.00000670

Table 3.17: CC matrix for Model three continued

	15	16	17	18	19	20	21
1	0.16078100	0.02871300	0.02233400	0.00372400	0.00066253	0.02090400	0.00371249
2	0.92389600	0.16467900	0.12557600	0.02090400	0.00371249	0.11881500	0.02106274
3	0.16467900	0.03091300	0.02090400	0.00371249	0.00069538	0.02106300	0.00393805
4	0.11881500	0.02106300	0.01660400	0.00274527	0.00048474	0.01543700	0.00272114
5	0.02106300	0.00393805	0.00274527	0.00048474	0.00009040	0.00272114	0.00050661
6	0.12103100	0.02258545	0.01543750	0.00272114	0.00050661	0.01546726	0.00287434
7	0.01546730	0.00287434	0.00202615	0.00035504	0.00006580	0.00199669	0.00036942
8	0.02090390	0.00371249	0.00298411	0.00049416	0.00008739	0.00274527	0.00048474
9	0.68405000	0.12103072	0.09353415	0.01543750	0.00272114	0.08791010	0.01546726
10	0.02258540	0.00438959	0.00272114	0.00050661	0.00009837	0.00287434	0.00055710
11	0.01543750	0.00272114	0.00221750	0.00036408	0.00006390	0.00202615	0.00035504
12	0.00272114	0.00050661	0.00036408	0.00006390	0.00001186	0.00035504	0.00006580
13	0.08791010	0.01546726	0.01236084	0.00202615	0.00035504	0.01141466	0.00199669
14	0.00287434	0.00055710	0.00035504	0.00006580	0.00001274	0.00036942	0.00007139
15	0.08904736	0.01651611	0.01141466	0.00199669	0.00036942	0.01137070	0.00209988
16	0.01651611	0.00319501	0.00199669	0.00036942	0.00007139	0.00209988	0.00040504
17	0.01141466	0.00199669	0.00164994	0.00026856	0.00004677	0.00149726	0.00026033
18	0.00199669	0.00036942	0.00026856	0.00004677	0.00000863	0.00026033	0.00004794
19	0.00036942	0.00007139	0.00004677	0.00000863	0.00000166	0.00004794	0.00000923
20	0.01137070	0.00209988	0.00149726	0.00026033	0.00004794	0.00146673	0.00026963
21	0.00209988	0.00040504	0.00026033	0.00004794	0.00000923	0.00026963	0.00005185
22	0.01208893	0.00232730	0.00146673	0.00026963	0.00005185	0.00153553	0.00029471
23	0.00146673	0.00026963	0.00019835	0.00003427	0.00000628	0.00019109	0.00003496
24	0.00026963	0.00005185	0.00003427	0.00000628	0.00000121	0.00003496	0.00000670
25	0.00153553	0.00029471	0.00019109	0.00003496	0.00000670	0.00019699	0.00003768
26	0.00019699	0.00003768	0.00002514	0.00000458	0.00000087	0.00002552	0.00000486

Table 3.17: CC matrix for Model three continued

	22	23	24	25	26
1	0.02106300	0.00274527	0.00048474	0.00272114	0.00035504
2	0.12103100	0.01543750	0.00272114	0.01546726	0.00199669
3	0.02258500	0.00272114	0.00050661	0.00287434	0.00036942
4	0.01546700	0.00202615	0.00035504	0.00199669	0.00026033
5	0.00287434	0.00035504	0.00006580	0.00036942	0.00004794
6	0.01651611	0.00199669	0.00036942	0.00209988	0.00026963
7	0.00209988	0.00026033	0.00004794	0.00026963	0.00003496
8	0.00272114	0.00036408	0.00006390	0.00035504	0.00004677
9	0.08904736	0.01141466	0.00199669	0.01137070	0.00146673
10	0.00319501	0.00036942	0.00007139	0.00040504	0.00005185
11	0.00199669	0.00026856	0.00004677	0.00026033	0.00003427
12	0.00036942	0.00004677	0.00000863	0.00004794	0.00000628
13	0.01137070	0.00149726	0.00026033	0.00146673	0.00019109
14	0.00040504	0.00004794	0.00000923	0.00005185	0.00000670
15	0.01208893	0.00146673	0.00026963	0.00153553	0.00019699
16	0.00232730	0.00026963	0.00005185	0.00029471	0.00003768
17	0.00146673	0.00019835	0.00003427	0.00019109	0.00002514
18	0.00026963	0.00003427	0.00000628	0.00003496	0.00000458
19	0.00005185	0.00000628	0.00000121	0.00000670	0.00000087
20	0.00153553	0.00019109	0.00003496	0.00019699	0.00002552
21	0.00029471	0.00003496	0.00000670	0.00003768	0.00000486
22	0.00169658	0.00019699	0.00003768	0.00021461	0.00002741
23	0.00019699	0.00002514	0.00000458	0.00002552	0.00000334
24	0.00003768	0.00000458	0.00000087	0.00000486	0.00000063
25	0.00021461	0.00002552	0.00000486	0.00002741	0.00000354
26	0.00002741	0.00000334	0.00000063	0.00000354	0.00000046

APPENDIX N

Table 3.18: CC Matrix Inverse for Model three

	1	2	3	4	5	6	7
1	-26984.3606	41071.9368	-13484.3435	159037.8715	-30085.1661	-35197.2652	1183436.0373
2	-26296.8465	72968.2769	-30008.2374	221466.2358	48099.0610	-29776.3115	517756.3167
3	-26887.1102	147315.4876	-104640.3082	494508.2865	331065.2510	-182169.7171	5243144.2844
4	9747.6202	-79486.8395	40269.3746	-191639.3615	-147016.9268	55208.7909	1480928.1585
5	133025.4447	-379710.6008	62451.4478	-946363.0157	-1742917.3443	-1261968.2414	3421328.4133
6	57373.4352	-83155.6760	85496.6841	-352290.1143	-21393.9619	-122524.3910	-5222521.4477
7	-369477.1748	420517.2110	-726074.5796	2738754.2263	-2386238.4366	5619521.4156	-11245660.8700
8	-36306.0104	-32468.1982	-86897.6745	146589.4661	-340392.1100	362348.6262	14327932.1423
9	25826.1967	-79239.2241	35208.4288	-244763.2825	-27838.9090	-67.4706	-669163.3541
10	-546680.0945	1434860.9343	-260994.6950	3796475.3990	-3869759.9569	4563485.2731	26452544.0543
11	-300980.0769	842781.5372	-34335.0991	1945699.4486	-2278124.6494	3875693.4037	-13449110.6277
12	117845.0907	-1040946.3299	-498498.1013	-5705474.0052	-10658910.6036	12861304.5839	-13918184.7011
13	27866.9315	139018.5139	-100549.8849	320945.3327	134501.2813	99708.4650	-378088.7985
14	-1269021.0839	-978437.7949	-787445.8592	-136542.4007	-380991.8432	1896062.2857	-16257109.9780
15	-7212.4159	-116890.7462	71097.8209	-287523.0736	-503839.6037	532098.6555	1496554.3160
16	1277119.6207	-3695345.0584	1165555.9401	-10295527.2861	1193767.0592	-430953.9008	-61768892.9747
17	976407.6979	-2585156.0235	793073.2954	-7014126.5064	4166226.4258	-6758160.2800	-33403457.6026
18	-6181492.6655	12416976.9914	-2170883.9304	36107367.5980	16823168.4445	-16755594.4773	98311469.7813
19	240328.2620	13117163.0360	3275695.8834	3456156.2068	-47721791.1973	60328846.2964	-226027579.0234
20	237766.8527	-1175781.3934	717941.1895	-4277703.7254	-3432707.9085	4770778.9522	-17900535.3156
21	-4288067.7966	11868126.8378	-412887.7699	25935859.6490	15203827.7429	-14615574.6884	214902513.4054
22	-327411.9175	1612789.6952	-1033897.0150	4932229.0335	4742920.9314	-7013687.2212	10387892.5317
23	755572.9624	4231347.3898	1200704.0061	1628437.0812	18423593.3061	-15567400.3500	133117553.6164
24	5503859.3694	-28810032.8074	-10078335.2235	8089585.4352	123491344.3185	-126213784.6675	107091438.3473
25	842975.6849	-3355555.0190	3681386.2993	-15787430.9274	9862981.5060	-20509939.5007	-53787848.8965
26	80540580.7823	-139148405.8090	38171448.3269	-384730091.7202	12666269.5809	-55350753.2408	-2270361546.6196

Table 3.18: CC Matrix Inverse for Model three continued

	8	9	10	11	12	13
1	675662.2317	-72792.4102	-797642.4815	-3264999.3632	-1155322.2200	152028.7558
2	2125323.8272	-121512.3674	10143549.3467	4087629.0695	-1299418.0456	-500412.6588
3	1581039.0645	-341705.9221	42393034.8543	32222504.9464	-41239639.6107	-1856314.2443
4	-3203203.1679	104052.4695	-25002837.5346	-17185428.7235	28295014.3538	1758713.9364
5	-7762006.6310	641921.0248	-46343762.1587	-19637671.8916	30087774.6357	2082947.6803
6	1570357.3724	286862.0563	-31999314.4048	-22492241.9941	-1116186.9171	-671575.7029
7	-12748133.5647	-1927244.1496	71532771.9188	9972527.6264	65963507.4815	14248406.9434
8	9528289.7688	-130890.1907	-5300933.1299	-19099448.4322	15670412.0515	3022256.7740
9	-1862434.7946	143085.9569	-9836072.0104	-3890504.7535	1554675.9362	438981.2040
10	-12057041.3155	-2892467.8214	65956712.6107	-3622496.6391	37498953.5078	3850582.7154
11	-20139618.5855	-1559514.6052	83600599.5423	65156423.1847	5048448.3820	-2467470.3791
12	-168868140.8997	2118703.0781	-314620315.6862	-52959374.5937	79329991.3302	8638867.8828
13	2495867.4971	-299498.0743	28560073.2332	19324672.1170	-30578558.4570	-1384684.8444
14	-15488494.4513	1012978.5402	121023101.6985	121662805.8540	-25468975.5421	-12142611.9531
15	-9479830.5792	168749.3821	-34715504.1363	-18600331.1956	35022970.1718	2323724.5522
16	-68989469.1395	6718942.8032	-343399985.4684	-90970935.8607	63243742.0016	10134287.9761
17	-9185974.3369	5439487.5085	-222824980.9380	-55897905.3949	-42064007.1724	-4355398.9359
18	509527887.9947	-23290840.2502	1318007083.9773	127842928.7369	-18477619.7557	22531082.2273
19	36437897.6915	-32194173.5595	-2353365641.0758	-2845949652.3851	2749036340.5432	286351587.6415
20	-46416269.5665	1164088.0964	-110635168.6549	-41639960.3851	134113612.6390	18737271.5804
21	381733792.5448	-15424461.5384	865068384.3367	-261187276.0839	-256523203.8634	-61199765.6880
22	102204992.4790	-2802751.6401	297052180.5030	96005308.6023	-9917172.3881	-10816213.1130
23	76772625.8778	-450430.8278	710456557.0225	252068394.5653	-798048525.6154	-150104534.7681
24	266855802.7826	4758328.6716	6134816269.2833	5745190224.7002	-4316343786.1400	143235701.0447
25	111383106.9865	11478024.7076	-1046013312.4172	-258793104.1094	211324083.4751	6294242.0735
26	-3279637494.6650	337369674.7608	-15991855797.9552	-1875750955.8718	41000894.2896	-938323061.3283

Table 3.18: CC Matrix Inverse for Model three continued

14	15	16	17	18	19
6103120.4625	236390.6763	-3798054.7103	1478592.0775	20450078.9032	-85238988.3165
6945997.4301	891209.0037	-10883473.5992	-12101138.6280	34313518.7241	56548806.6294
-16139609.4964	3497315.3274	-27206952.3184	-49776238.9686	81037442.2434	345739091.1092
5124349.0951	-1513375.2379	18140928.3029	30306700.1136	-70011742.4241	-269861227.6672
20298139.4329	-3788768.6855	46949153.2239	47247348.5251	-128168668.4706	-189479714.1656
21584562.4898	-1432933.8659	38111122.1750	43564050.6543	-124075912.9107	-627862525.5644
-101905073.2690	1954636.0011	-161917611.7302	-100692177.0782	339995942.7123	2207001363.3484
13265332.3856	-1010630.9323	-7751045.9513	-547354.1278	-21414855.9941	-37549094.1129
-7903292.4143	-946665.0104	9938141.6990	11551624.5974	-31968524.5355	-50504586.3647
-39549239.9654	8022681.8708	-86784768.0783	-46320685.3582	160901717.2656	41183291.4517
-81307859.3864	7493222.5078	-88194892.2377	-78315545.2928	284120471.2398	919849813.6770
337564822.8163	-22657616.5606	402174531.9587	436772042.3829	-1079458521.3705	-4071587103.7621
-23142106.9523	1972220.0694	-6946730.1558	-33290727.6488	41499169.2530	396172465.1773
-73148858.0113	11942179.3482	-31515465.1332	-101987144.9791	427333662.2573	1355638593.1935
11991386.4659	-2794315.6200	17653677.6311	40306624.6629	-61050134.5387	-161777867.5397
235653067.2686	-37706199.9112	412577849.5244	358350757.7969	-931479630.5241	-1716348188.1740
166589059.4564	-20772396.1910	241993847.5909	217061566.8091	-705932962.8293	-2236847803.9968
-1368227603.0201	92348715.0706	-2040961418.0993	-1767857977.6120	4560978251.7756	17213595744.4757
-1268223663.5435	-15207704.3978	2015807788.9298	3124834690.9692	-7411906419.2563	29009091300.8083
26660531.8769	-16644389.4179	106834563.3947	111343828.3073	-159165911.2958	1038868184.9114
-799780121.7851	82230969.8075	-1716062327.8054	-423967467.5405	1894080573.5863	6482044402.1679
-314611642.7654	23682738.4089	-342431980.6374	-372326709.0173	1051209648.6458	3703342868.5945
-535041999.7197	103391602.3966	255024937.0595	-56554030.1298	-12667011.9893	-1981357163.7662
508163114.4185	336189612.8357	-6847482449.7356	-9632640744.3763	23413372693.4721	10059872692.9011
826504760.9350	-26561532.7849	945437953.8469	584633253.2382	-2393546750.3804	-22226843926.9801
13642145447.6316	-1776992502.7357	24960824398.5156	17879712071.8692	-51714634896.1927	-191282369395.9890

Table 3.18: CC Matrix Inverse for Model three continued

20	21	22	23	24	25	26
-2170739.8723	84486863.9802	5970495.7305	-13093219.1222	-49425082.7578	-120717993.7398	107011318.1897
13671168.9825	114341111.7436	-10125684.7905	-7201187.3843	-152114223.6019	-141456950.9246	-868864729.1519
57152372.3117	162325561.9229	-55025870.6579	-58844778.7762	49630330.3937	-316068200.3402	-2652034040.3877
-36489084.0639	-103113156.5124	33640193.6366	-3888351.7491	20632218.9446	90560850.0988	2312282020.6851
-50017401.0643	-499296168.7136	52298450.2166	45009100.7532	612256805.7675	584023288.0563	2657098110.3248
-31056472.8012	-211028968.5656	15215230.6520	7580742.2984	660659850.7010	242305736.1093	2862803280.3041
21462840.1291	1669232611.5474	87705630.8303	449191411.0596	-5158496219.7121	-2255359765.0896	-3927392385.5702
-15406246.1894	50673219.9136	29313520.4499	-59413397.8785	-438299831.8621	-202827258.1681	1243538812.0822
-14289190.7150	-116796958.8821	10417711.6613	9873291.6699	125867011.1119	162043666.2179	821320586.1011
45561387.5607	2103141040.6877	-25716052.8986	300713598.8578	-1946700974.7297	-3364427266.1217	-2630134076.0480
75757755.9736	1070167868.6768	-91905606.8242	43533774.5531	-1479489407.2699	-1189392437.9064	-6082339535.4187
-498790367.3791	-2951339318.5306	192534109.9384	1242903199.0517	4324190014.9780	2211771214.9481	29696561839.3173
54551059.5289	54888449.6335	-50893048.9041	-40733619.3089	284761184.0169	-167501759.8416	-2401117426.7186
203334982.1032	326623986.7034	-270133102.7237	-417793369.0876	-146641539.6171	61427309.2897	-11456927750.5832
-53370007.6491	-94696869.5678	54847549.2478	68309505.2647	17212200.2669	128004456.4778	2003502945.4013
-417777475.8074	-5775557251.3827	273534773.5779	399073635.6115	4762150990.7199	7384912487.9383	24355992496.7355
-232943994.4418	-3376849949.6704	178015779.4699	194612746.4956	4916646344.6627	4926007902.7596	13147228443.0369
1641489665.7620	20451874753.2039	-220926313.8921	-1522797925.7959	-33816714201.0169	-22858066362.3023	-106637953139.8160
-3372291333.0706	9098055743.6468	2199942581.3508	6776505307.7259	-114892091486.0490	-14273297507.8918	231014520842.8960
-176265013.1187	-1841840477.8141	157425017.5494	164090187.9770	-1364565615.6490	1992593514.9192	9410293901.4671
646652414.0581	15723462808.7435	52737749.4065	-492466195.3394	-24847975968.2732	-14706384955.1141	-56054794182.0858
445805839.3571	3033633885.1440	-243172592.2532	-981158674.9882	-4128601077.2481	-2557259435.1506	-27839408338.1050
709596955.6711	-22334871.9006	-2267465456.4201	566914230.8042	12487888687.7493	2342142969.2742	-49420512985.8573
6818322699.8287	-15650365045.5666	-2873522640.0693	-20877634204.7542	189499289880.0600	15240473957.6451	-569060341504.7000
-1674696760.6336	-5351892502.3476	534050477.5883	162913929.1686	15742159261.9561	13924373455.3662	62457930002.3093
-9002323812.2685	-225846335418.2790	3357507719.4320	-1317845292.9496	385610268995.2980	266251860166.356	1059064830857.2800

Table 3.19: Z Matrix for the control Mixes (Model three)

S/N	Z ₁	Z ₂	Z ₃	Z ₁ Z ₂	Z ₁ Z ₃	Z ₂ Z ₃	Z ₁ Z ₂ Z ₃
C1	0.13260366	0.70953483	0.15786150	0.09408692	0.02093301	0.11200824	0.01485270
C2	0.10200000	0.73484211	0.16315789	0.07495389	0.01664211	0.11989529	0.01222932
C3	0.11184211	0.73552632	0.15263158	0.08226281	0.01707064	0.11226454	0.01255590
C4	0.13600000	0.73066667	0.13333333	0.09937067	0.01813333	0.09742222	0.01324942
C5	0.12805813	0.73861743	0.13332445	0.09458597	0.01707328	0.09847576	0.01261062
C6	0.11333333	0.75333333	0.13333333	0.08537778	0.01511111	0.10044444	0.01138370
C7	0.12090909	0.78818182	0.09090909	0.09529835	0.01099174	0.07165289	0.00866349
C8	0.12818182	0.78090909	0.09090909	0.10009835	0.01165289	0.07099174	0.00909985
C9	0.11727273	0.79181818	0.09090909	0.09285868	0.01066116	0.07198347	0.00844170

Table 3.19: Z Matrix for the control Mixes (Model three) continued

S/N	Z_1Z_1	Z_2Z_2	Z_3Z_3	$Z_1Z_1Z_2$	$Z_1Z_1Z_3$	$Z_1Z_2Z_2$	$Z_1Z_3Z_3$
C1	0.01758373	0.50343968	0.02492025	0.01247627	0.00277579	0.06675795	0.00330452
C2	0.01040400	0.53999292	0.02662050	0.00764530	0.00169749	0.05507928	0.00271529
C3	0.01250866	0.54099896	0.02329640	0.00920045	0.00190922	0.06050646	0.00260552
C4	0.01849600	0.53387378	0.01777778	0.01351441	0.00246613	0.07260683	0.00241778
C5	0.01639888	0.54555570	0.01777541	0.01211250	0.00218637	0.06986284	0.00227629
C6	0.01284444	0.56751111	0.01777778	0.00967615	0.00171259	0.06431793	0.00201481
C7	0.01461901	0.62123058	0.00826446	0.01152244	0.00132900	0.07511242	0.00099925
C8	0.01643058	0.60981901	0.00826446	0.01283079	0.00149369	0.07816771	0.00105935
C9	0.01375289	0.62697603	0.00826446	0.01088979	0.00125026	0.07352719	0.00096920

Table 3.19: Z Matrix for the control Mixes (Model three) continued

S/N	$Z_2Z_2Z_3$	$Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2$	$Z_1Z_1Z_2Z_3$	$Z_1Z_1Z_3Z_3$	$Z_1Z_2Z_2Z_3$	$Z_1Z_2Z_3Z_3$
C1	0.07947374	0.01768179	0.00885235	0.00196952	0.00043819	0.01053851	0.00234467
C2	0.08810411	0.01956186	0.00561809	0.00124739	0.00027696	0.00898662	0.00199531
C3	0.08257353	0.01713511	0.00676717	0.00140428	0.00029141	0.00923520	0.00191643
C4	0.07118317	0.01298963	0.00987453	0.00180192	0.00032882	0.00968091	0.00176659
C5	0.07273591	0.01312923	0.00894650	0.00161489	0.00029150	0.00931442	0.00168130
C6	0.07566815	0.01339259	0.00728936	0.00129015	0.00022835	0.00857572	0.00151783
C7	0.05647551	0.00651390	0.00908177	0.00104749	0.00012082	0.00682840	0.00078759
C8	0.05543809	0.00645379	0.01001968	0.00116644	0.00013579	0.00710616	0.00082726
C9	0.05699782	0.00654395	0.00862273	0.00098998	0.00011366	0.00668429	0.00076743

Table 3.19: Z Matrix for the control Mixes (Model three) continued

S/N	$Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3$	$Z_1Z_1Z_2Z_3Z_3$	$Z_1Z_2Z_2Z_3Z_3$	$Z_1Z_1Z_2Z_2Z_3Z_3$
C1	0.01254584	0.00139744	0.00031091	0.00166362	0.00022060
C2	0.01437488	0.00091664	0.00020352	0.00146624	0.00014956
C3	0.01260333	0.00103288	0.00021434	0.00140958	0.00015765
C4	0.00949109	0.00131660	0.00024026	0.00129079	0.00017555
C5	0.00969747	0.00119279	0.00021530	0.00124184	0.00015903
C6	0.01008909	0.00097192	0.00017202	0.00114343	0.00012959
C7	0.00513414	0.00082562	0.00009523	0.00062076	0.00007506
C8	0.00503983	0.00091088	0.00010604	0.00064601	0.00008281
C9	0.00518162	0.00078388	0.00009000	0.00060766	0.00007126

Table 4.1: Sieve analysis Laboratory recording sheet:**APPENDIX P**

SIEVE SIZE	MASS RETAINED (g)	PERCENTAGE RETAINED (%)	CUMULATIVE PERCENTAGE	PERCENTAGE PASSING (%)
4.75	0	0	0	100
2.36	40	8.00	8	92
1.18	92	18.40	26.40	74
600	92	18.40	44.80	55
425	68	13.60	58.40	42
300	58	11.60	70.00	30
212	35	7.00	77.00	23
150	16	3.20	80.20	20
75	12	2.40	82.60	17
WEIGHT OF DRY SOIL PASSING 4.75mm SIEVE				500g
WEIGHT OF DRY SOIL + 75 μ SIEVE				413g
WEIGHT OF DRY SOIL - 75 μ SIEVE				87g

Table 4.1: Atterberg limits laboratory recording sheet:**APPENDIX Q**

Test number	1	2	3	4	5	6
Type of test	LL	LL	LL	LL	PL	PL
No. Of blows	12	23	33	44		
Container No.	34	7	23	17	32	47
Mass Of Wet Soil + Container g	42.50	44.50	44.40	44.70	27.00	26.40
Mass of Dried Soil + Container g	35.50	37.00	37.00	37.40	25.20	24.40
Wt. of Container g	16.50	16.20	15.80	15.80	16.60	16.70
Wt. of Moisture g	7.00	7.50	7.40	7.30	1.80	2.00
Wt of Dried Soil g	19.00	20.80	21.20	21.60	8.60	7.70
Moisture Content (m) %	36.8	36.1	34.9	33.8	20.9	26.0

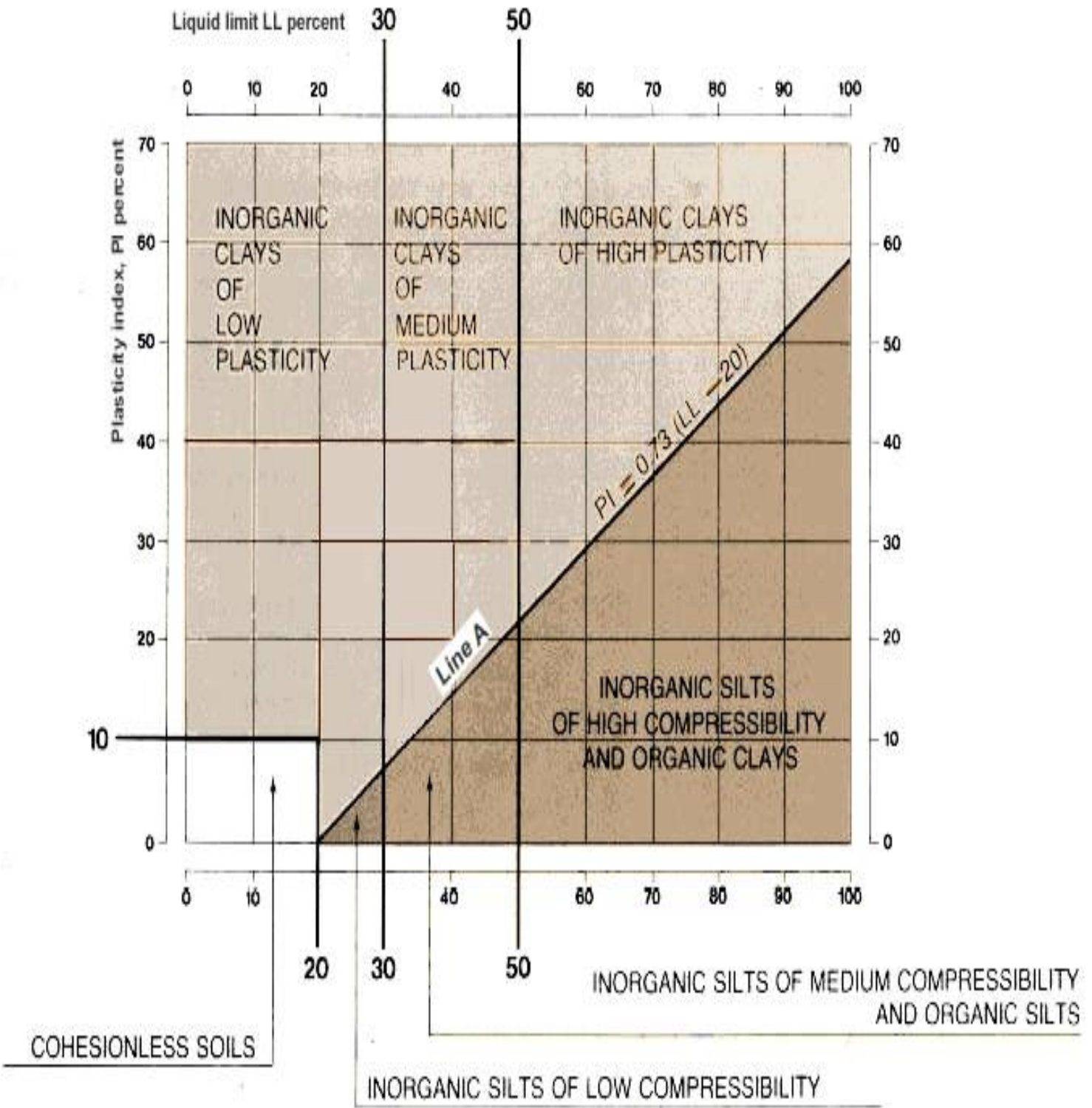
Table 4.3: Compaction test laboratory recording sheet:

APPENDIX R

Test number	1	2	3	4	5
Mass of mould + base + compacted specimen (m_2) g	9912	10098	10185	10179	10240
Mass of mould + base (m_1) g	5280	5283	5138	5148	5332
Mass of compacted specimen ($m_2 - m_1$) g	4632	4815	5047	5031	4908
Bulk density $\rho = m_2 - m_1/1000$ Mg/m ³	2.00	2.09	2.19	2.18	2.13
Moisture content container N0.	A63	A64	A60	A39	B25
moisture content (w) %	6.63	8.38	10.09	11.14	12.05
Dry density $\rho_d = 100 \rho / (100 + w)$ Mg/m ³	1.88	1.93	1.99	1.96	1.90

APPENDIX S

PLASTICITY CHART



APPENDIX T

Table 4 Percentiles of the F-Distribution (Continued)

Upper 5% point of the F-distribution

	Degrees of Freedom for Numerator												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1	161	200	216	225	230	234	237	239	241	242	243	244	245
2	18.5	19.0	19.2	19.2	19.3	19.3	19.4	19.4	19.4	19.4	19.4	19.4	19.4
3	10.1	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.76	8.74	8.73
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.94	5.91	5.89
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.70	4.68	4.66
6	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.03	4.00	3.98
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.60	3.57	3.55
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.31	3.28	3.26
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.10	3.07	3.05
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.94	2.91	2.89
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.82	2.82	2.79	2.76
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.72	2.72	2.69	2.66
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.63	2.60	2.58
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.57	2.53	2.51
15	4.54	3.68	3.29	3.05	2.90	2.79	2.71	2.64	2.59	2.54	2.51	2.48	2.45
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.46	2.42	2.40
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.41	2.38	2.35
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.37	2.34	2.31
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.34	2.31	2.28
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.31	2.28	2.25
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.28	2.25	2.22
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.26	2.23	2.20
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.24	2.20	2.18
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.22	2.18	2.15
25	4.24	3.39	2.99	2.75	2.60	2.49	2.40	2.34	2.28	2.24	2.20	2.16	2.14
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.18	2.15	2.12
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.17	2.13	2.10
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.15	2.12	2.09
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.14	2.10	2.08
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.13	2.09	2.06
32	4.15	3.29	2.90	2.67	2.51	2.40	2.31	2.24	2.19	2.14	2.10	2.07	2.04
34	4.13	3.28	2.88	2.65	2.49	2.38	2.29	2.23	2.17	2.12	2.08	2.05	2.02
36	4.11	3.26	2.87	2.63	2.48	2.36	2.28	2.21	2.15	2.11	2.07	2.03	2.00
38	4.10	3.24	2.85	2.62	2.46	2.35	2.26	2.19	2.14	2.09	2.05	2.02	1.99
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.04	2.00	1.97
42	4.07	3.22	2.83	2.59	2.44	2.32	2.24	2.17	2.11	2.06	2.03	1.99	1.96
44	4.06	3.21	2.82	2.58	2.43	2.31	2.23	2.16	2.10	2.05	2.01	1.98	1.95
46	4.05	3.20	2.81	2.57	2.42	2.30	2.22	2.15	2.09	2.04	2.00	1.97	1.94
48	4.04	3.19	2.80	2.57	2.41	2.29	2.21	2.14	2.08	2.03	1.99	1.96	1.93
50	4.03	3.18	2.79	2.56	2.40	2.29	2.20	2.13	2.07	2.03	1.99	1.95	1.92
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.95	1.92	1.89
70	3.93	3.13	2.74	2.50	2.35	2.23	2.14	2.07	2.02	1.97	1.93	1.89	1.86
80	3.96	3.11	2.72	2.49	2.33	2.21	2.13	2.06	2.00	1.95	1.91	1.88	1.84
90	3.95	3.10	2.71	2.47	2.32	2.20	2.11	2.04	1.99	1.94	1.90	1.86	1.83
100	3.94	3.09	2.70	2.45	2.31	2.19	2.10	2.03	1.97	1.93	1.89	1.85	1.82
125	3.92	3.07	2.68	2.44	2.29	2.17	2.08	2.01	1.96	1.91	1.87	1.83	1.80
150	3.90	3.06	2.66	2.43	2.27	2.16	2.07	2.00	1.94	1.89	1.85	1.82	1.79
200	3.89	3.04	2.65	2.42	2.26	2.14	2.06	1.98	1.93	1.88	1.84	1.80	1.77
300	3.87	3.03	2.63	2.40	2.24	2.13	2.04	1.97	1.91	1.86	1.82	1.78	1.75
500	3.86	3.01	2.62	2.39	2.23	2.12	2.03	1.96	1.90	1.85	1.81	1.77	1.74
1000	3.85	3.00	2.61	2.38	2.22	2.11	2.02	1.95	1.89	1.84	1.80	1.76	1.73