QUALITY ASSESSMENT OF HADASSA STEEL

BY

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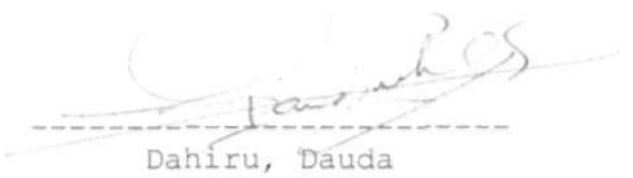
Zaria

July, 1997.

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DECLARATION

I hereby declare that this Thesis has been prepared by me and that it is a record of my research work. It has not been presented in any previous publication for a higher degree. All Quotations are indicated and the sources of information are specifically acknowledged by means of references.



Dahiru, Dauda
July, 1997

DEDICATION

This Thesis is dedicated to my late brother, Musa Dahiru Danwata.

CERTIFICATION

This thesis entitled " **Quality Assesment of Hadassa Steel** " by Dahiru Dauda meets the regulations governing the award of the degree of Master of Science in Structural Engineering of Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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ABSTRACT

An assessment of the quality of various sizes of steel and the management of the steel rolling company producing such product, as it affects quality of steel, was undertaken. Various steel samples were obtained directly from the company and physical test were carried out on them. Field survey was also undertaken so as to get information on the company especially as regards to factors affecting the quality of its products.

Results of test as well as survey of the management of the company shows that poor management results into poor quality control and inferior product. Most of the High tensile steel reinforcement bars failed as values of characteristic strength of 270, 355 and 395 N/mm^2 are far below the values specified by BS 4449:1970, CP 110 and BS 8110: 1984. Out of six different diameters produced by the company, only one has a value of characteristic strength of 309.4 N/mm^2 as compared to 250 N/mm^2 provided in BS 4449. Most samples passed the test on deviation on cross-sectional area as samples A,C,D,E and F have average effective cross-sectional area of 467, 190, 109, 76.7 and 75.7 mm^2 this represent average percentage deviation of -5,-5.6, -3.5, -2.3 and -3.6 percent which is not up to the maximum deviation of ±8 as contained in Bs 4449: 1970, While sample B with an average percentage deviation of -9.4 fails.

Most samples also failed to satisfy the standard requirement on deviation on Nominal mass, deviation on nominal density and specific gravity. Cracks were observed during Bend test on the 25 millimetres diameter samples, as such they are deemed to have failed the test.

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ABBREVIATIONS

x	-	Carbon content percent
y	-	Tensile strength
z	-	Elongation percent
t	-	Metric tonnes
%	-	Percentage
°c	-	Degree centigrade
fy	-	Characteristic strength
BS	-	British standard
Pc	-	Plain coil
PB	-	Plain Bar
DC	-	Deformed coil
DB	-	Deformed Bar
CP	-	Code of practice
L/S	-	Litre per second
ToT	-	Total
DSC	-	Delta Steel Company
KVa	-	Kilovolts
MVa	-	Megavolts
NSC	-	National Steel Council
KPa	-	Kilo Paschal
HSRC		Hadassa Steel Rolling Company
NEPA		National electric Power Authority
NSDA		Nigerian Steel Development Authority
CISCO		Continental Iron and Ore mining Company limited.

CHAPTER ONE

INTRODUCTION

The quality of steel produced by the steel rolling companies as well as the management as it affects the quality of steel in Nigeria cannot be over-emphasized. Since its quality will affect the construction industry as well as life. Because most of the steel rolling companies products are used in construction industry, as such, failure in construction industry in form of buildings and structures means a lot to life. Thus, a regular check on the quality of the products and the management of the company as it affect the final product is of vital importance. Most of the products of the steel rolling companies are reinforcing steels which are mainly used in construction industry.

Steel, which is an alloy of iron and carbon with some other ingredients such as chrome, manganese, nickel, etc has been described as a necessary ingredient for national development /4/. This is because steel development is fundamental to the industrial and technological advancement of any nation. Steel is not just an indispensable tool for industrial and technological development but it also has its political and defence implications. The economic progress of a nation is now being measured in terms of the amount of steel that a country produces and consumes /7/. The strength of a country is partly dependent on steel-since it is needed in war for manufacture of military weapons and supplies. The most

powerful nations of the world today economically, politically and militarily are the greatest producers of steel /7/.

The applicability of steel is wide and varied most especially for all heavy civil engineering works like bridges, fly-overs, multi-storey buildings, dams, etc. In addition, it is essential in modern construction of home, offices, factories, hospitals, etc. This undoubtedly makes steel one of the principal constructional material in the construction industry; and it wide use is largely due to its desirable properties some of which are high tensile strength , ductility, hardness, toughness, etc.

There is no doubt that use of indigenous material is a great advantage to the country's economy. However, expert have, at the 7th Annual conference in Sokoto, identified lack of quality control in the production of construction material as responsible for structural failures in Nigeria /35/. This brings the need for strict and meticulous production control.

In this thesis, a general survey of the three inland steel rolling companies were carried out with respect to ascertaining the quality of their product. Out of the these inland steel companies in Nigeria, one of them was chosen in order to study the quality of its products as well as its management as it affects the final product.

The name of the inland steel rolling company chosen is called Hadassa steel rolling company (HSRC), to avoid legal implications. The company chosen out of the three inland steel rolling companies has nothing to do with the quality of

products, location or as a result of bad management within the company but simply for research purposes.

The results of tests as well as survey of the management indicate that poor management results into poor quality control and inferior products. Most of the high tensile steel bars failed as values of characteristic strength fall below the one specified in CP 110, BS 8110 and BS 4449. For instance samples B,C,D have 270, 355 and 398 N/mm^2 respectively as their characteristic strength is far below the value the 410 N/mm^2 specified in the BS 4449 and CP 110. Out of six different diameters tested, only one has a value that satisfies the code requirement. The largest sample diameter of 25 millimeter failed Bend test as cracks were observed during test. Apart from deviation on cross-sectional area test, most samples failed the remaining tests. These test include, Deviation on nominal mass test; Deviation on nominal density test; and Specific gravity test. During the analysis, it was observed that percentage of ultimate strength above the yield strength is far higher than the one provided in BS 4449. Elongation value is very high in most samples while in one of the sample, it is too small.

CHAPTER TWO

LITERATURE REVIEW

2.1 Preamble

Material like steel are the foundation of technology since without suitable materials nothing can be constructed. No matter how brilliant a new piece of Engineering design may be, it is to no avail if there are no suitable material available for converting the design into "hardware".

In the past, man could only use material naturally available, while early development was largely empirical there has been intensive study of the science of material during this century and the present-day engineering materials are based on sound scientific theory and practice.

That explains the reason why Tremlett /36/ asserted that design engineers should be concerned with three main aspect of their materials apart from cost and delivery. These include, among others, mechanical and physical properties as supplied by the manufacturer. In the endeavour to fix standards of suitability for steels for the various duties, it is thus desirable in the first place to specify the requirements, and then to carry out such tests as will enable one to decide whether the various materials comply sufficiently with the requirements demanded. Conventional tests on sample will reveal the basic properties such as tensile strength, ductility, hardness, toughness, etc of the sample but the engineer must be aware of the limitation inherent in such information in that it

may not properly represent the bulk of material. Another factor to be considered is the ability of such material to meet service condition without failure. This is only possible when all the necessary information regarding such conditions and the properties of the materials is known added to the fact that the design engineer is competent and experienced. Research has shown that the occurrence of major failures in bridges, pressure vessels, storage tanks, etc were as a result of lack of correct information on service condition /36/.

The third aspect of material that should be considered is its reliability in respect of properties and performance in a continuing supply of material. This is something which the conventional testing of samples can take care only in a limited range of applications. A degree of variability is inherit in steel products manufactured to the same specification by one steel maker using the same melting, hotworking and heat treatment practices and facilities; the engineer should know this variability range and must work within this range. However, purchasing material from several sources to the same nominal specification will tend to increase the chance of obtaining material outside the engineers variability range.

All these three aspect are affected by metallurgical control in extrusion of the metal from the ore, its subsequent forming to shape and the conferring of preferred mechanical properties suited to the particular need of the application.

2.2 Historical Development of Steel

Steel was described by professor Albert Sauver as a malleable alloy of iron and carbon, usually containing substantial qualities of manganese /25/. It is a ferrous metal which is produced by removing impurities from pig iron and then accurately controlling the proportion of all other ingredient such as carbon, chrome, nickel, copper and manganese.

Production of steel on a large scale dated from 1856 /13/. Few years later, that was in 1889, the forth railway bridge and Eiffel tower were erected in steel. However, steel in its modern form did not emerge until 1956 when Henry Bessemer first obtained an English patent for the production of steel /21/. In another continents Williams Kelly an American, also obtained an American patent in 1957 for the invention of steel /21/.

The idea of reinforced concrete was suggested much earlier, that was in 1830 /21/ and the earliest successful use of tensile reinforcement in portland cement concrete is believed to be due to a French contractor J.L. Lambot /10/. He used a mesh of iron bars to build a reinforced concrete rowing boat for the Paris international exhibition of 1855. However, an Englishman by name William B. Wilkinson of Newcastle upon Tyne, took out the first patent for reinforced concrete in 1854 /10/. He proposed embedding either flat iron rods or second hand wire ropes in tension zones of concrete beams. This patent revealed that wilkinson also understood the need to develop good bond between the concrete and the steel reinforcement. From then on ward, the use of steel for large structures was established.

Steel is now produced in a wide range of qualities for various forms of applications or use in the construction industry as reinforcement to the extent that "most construction are only possible with the use of steel reinforcement" /12/. Especially considering the fact that concrete is weak in tension. This encourage the use of steel to take care of the imposed tensile forces on a structure.

2.3 Production of Steel

Three basic raw materials are needed in large quantities for the production of steel. These are: Iron ore, coal and limestone. Iron ore are iron bearing rocks that are distributed over the earth crust with more than 20 percent of iron /22/. The composition of the ore is an important consideration. The density of the ore should be such that it will not crumble too readily nor so dense as to impede chemical reactions. There are different types of iron ores /22/. There are magnetic iron ore, red hematite, brown hematite and spathic iron ore. Most ores require some preparation for smelting /30/.

1). By crushing and screening (sieving) to a suitable size and,

2) By concentration which involves the removal of unwanted materials, sometimes by washing and in the case of Magnetite, by magnetic separation. The carbonate ore are up-graded and made suitable for smelting by calcining which involves roasting in an excess of air. The concentrated ore is shipped to a steel plant often in the form of pellets.

3. By the direct reduction of the ore.

In this process, iron ore is finely ground and impurities are separated from the ore by a magnetic method. The powdered iron is blown by nitrogen gas into an Electric furnace which is lined with graphite. /33/. The inventor Mr. Rene Planiol /25/ claims that steel of excellent quality can be manufactured directly, and by adding alloying materials, alloys steel can be produced /25/.

LADDLE

When the production of iron (pig iron) is completed, it is tapped from the blast furnace and is usually handled in one of the two general ways: by casting into pigs, or, still molten in laddles. It should be noted however, that the blast furnace is so often operated in direct conjunction with a steel plant that the iron is very commonly not cast into pigs at all, but is iron directly into laddles which transport it to the steel furnaces. The laddles is build of steel, mounted on trunnions on a car-truck, and lined with firebrick. Its capacity is usually 20 tons or more /25/.

Apart from the transportation of pig Iron, laddle is used to transport molten steel to moulds. This type of laddle is called teeming laddle. It is normally suspended, and consist of a bucket-shaped steel shell lined with refractory material and provided with a valve in the bottom through which the molten metal is discharged.

i **THE OPEN-HEARTH FURNACE**

Molten pig iron, scrap iron, and steel, limestone, and high grade iron ore are all charged into an open -hearth furnace. Refining takes from 3 1/2 to 7 hours at temperature up to 1650°c continuous sampling is carried out by laboratory technicians to ensure that the steel adheres to specification, for each heat of steel is made to a specific formula. Technicians use spectrographic equipment in the chemical control of steel production. During the process, it may be necessary to remove some elements and add others. Impurities are removed by the use of oxidizing agents such as limestone, burnt lime may be added to hasten the absorption of sulphur and phosphorous. In some open-hearth furnaces, oxygen is injected through the furnace roof. As a result of doing this, greater heat is produced and the furnace heat time is reduced.

ii. **THE BESSEMER CONVERTER**

Bessemer converter is a big pot, set on massive trunions so that it can be tilted. The scrap and molten pig iron are charged into the converter first, through the top, and then the limestone or other fluxes are added. Air and fuel are injected from the bottom. When the steel is ready, it is tapped off through a port in the side of the converter.

iii THE BASIC OXYGEN FURNACE

Resembles a Bessemer converter but instead of using air injected at the bottom, pure oxygen is blown in from the top. The process was pioneered in North America in 1954 /33/ but it had been used previously in Europe for a number of years /33/. The principal raw material used is molten pig from a blast furnace though some scrap metal is used. Lime, rather than limestone, is used as the fluxing agent with flouspar added to it.

With the furnace returned to a vertical position the oxygen lance is lowered and the oxygen is turned on to aflow of up to 2832 L/S (600ft^3/min) and at a pressure of 1100 kpa (160 lb/in^2) /33/.This causes very rapid burning to remove the carbon and other impurities and allows the production of a batch of steel within a period of about one hour /9/.

iv. ELECTRIC FURNACES

Electric Furnace has long been used for producing alloy tool and other special steels. It is also used to produce carbon steel. The roof of an electric furnace is perforated so that three carbon or graphite electrodes can be lowered into the furnace. Heat is produced by the arcs between the huge electrodes and the charge in the furnace.

When specialty steel are being made, the charge is mostly selected scrap, along with some iron ore. To this are added the ingredients necessary to make the special alloy such ingredients

are of very high-grade. When carbon steel is being made, pre-reduced ore containing up to 98 percent iron is used as the ingredient (charge).

vi INGOTS

When it is ready, the molten steel is drawn from the furnace in giant laddles from which it is poured into ingot molds. This pouring into molds is known as teeming.

The molds containing the ingots are transported to a stripper building where they are allowed to cool. The molds are then removed and the ingots placed in soaking pots, where they are re-heated to a uniform temperature high enough for rolling. Ingots vary in size from about 8.1t to 215t (9 to 23 tons).

A great variety of products used in the construction industry are made from these ingots. They include rolled structural shapes, reinforcement bars, plates, pipes wire, boils, rivets, nails, sheet steel and many others. Subsequent treatment of the ingots depends to a considerable extent on which of these products is to be made from them.

vii SHAPING STEEL

Hot ingots go into a blooming mill where they receive their first shaping between huge rolls. If the steel is to be made into sheets or other flat products, the ingots is formed into a rectangular slab. If it is to become bars, rods, rolled structural shapes etc. the ingot is formed into a bloom, roughly square section.

A bloom which is to be made into a rolled shape is heated to 1200^{0}C in a continuous re-heating furnace. It then passes through a series of rolls; as it does so, the grooves and raised areas on the rolls give out shape. A bloom may make as many as 26 passes through the rolls before it is turned into s-shaped beam.

When rods and bars are being made, the bloom is further reduced to a billet by passing through a series of billet rolls becoming smaller in cross-section and greater in length with each stand of rolls. Finally the billets are cut into the required lengths and passed on to the rods or bar mills. Before being rolled into rods or bars, billets are heated in a three zone furnace and passed into the roll stands of a bar mill.

Slabs formed in the blooming mill are rolled into plates of various widths usually from 600-300mm (24-120inch) and in thickness of from 5 to 150mm (3/16 - 6 inch). Steel to be rolled thinner than plate goes to a hot-strip mill, where it is further reduced by being passed through a cold-reduction mill, where they may be made as thin as 0.18mm (0.007 inch) and rolled into coils. Sheets cut from these coils go into many diversified products, such as tin plate, galvanised sheets decking and automobile stampings.

Cold-reduced steel for tin products must be ductile. It is made so by controlled heating and cooling in a continuous annealing furnace, cold-rolled sheets are galvanised by being passed through galvanising pot and cooling tower.

2.3.2. New Techniques in Steelmaking

The need for better steel for advanced industrial equipment and highly sophisticated alloy and specialty steels for use in the world's new technologies in aerospace and nuclear energy has led to the development of a number of new processes in steel making. These new process may be divided into two categories. The first category is one in which molten metal is taken from conventional furnaces and worked to remove many impurities quickly before the steel solidifies. Among these processes are vacuum stream degassing, vacuum ladle degassing, argon-oxygen decaburisation and vacuum oxygen decarburisation. The second category of processes involves remelting steel and other raw materials and subjecting them to refining and purifying forces of very aggressive nature. Included in this group are electron-beam processing, vacuum-induction melting, consumable electrode melting and electroslag melting.

2.4 Types of Steels

There are an almost infinite number of kinds of steel available since it is possible to make steel to perform under most conditions. These are special grades of steel to perform at ultra-high temperature and some for very low temperatures. These are steels for strength, for electrical conductivity, for electrical resistance. These are steel to resist impact, corrosion or abrasion steels to take and hold a sharp edge, and steel to cut other steels. Consequently, steels have been

grouped into a number of classifications, based on the content of modifying elements. They are as follows:

a. **Carbon Steel**: A steel that owes its properties mainly to the presence of carbon, without substantial amounts of other alloying elements, except manganese.
Others include alloy steel, high-strength, low alloy steel, stainless and heat resisting steels, tool steels.

All steel contain carbon but the name(term) plain carbon steel is used to distinguish those steel which do not contain substantial proportion of alloying elements. These are sub-divided into: low carbon steel (up to 0.15 percent carbon) are soft and suitable for "iron" wire and thin sheet for tin plate

b. **Mild steels** (0.15 to 0.25 percent carbon) are strong, ductile and suitable for rolling into sections, strip and sheet. They are easily worked and welded but can not cast or heat treated. The group includes normal and high strength low alloy weldable structural steels.

c. **Medium carbon steel** (0.20 to 0.50 percent carbon) are suitable for forgings and for general Engineering purposes.

d. **High carbon steels** (0.05 to 1.50 percent carbon).

2.4.1 Steel Products

Rolled and welded structural shapes are among the most important steel products used in construction. They include the following S (standard beam) shapes, W (wide flange) shapes, WWF

(welded wide-flange) shapes, HP (bearing piles) shapes etc. Metric dimension have already been established for a number of these steel products, including plate, sheet, bar, rod, wire and WWF shapes.

Others include steel wire, Nail and screws, bolt and nuts, steel strapping, steel roofing, steel, decking, steel siding, open-web steel. Joist and most importantly reinforcing steel. Most reinforcing bars are rolled from new steel, but sometimes they are made from discarded rails or railway car axles that are cut and re-rolled to the required sizes. The strength grades range from the softest and most ductile structural grade up to a grade of very high strength, having a specified minimum yield point of 517 Mpa (75,000 psi) and a minimum tensile strength of 689 mpa (100,00 psi) sizes from 6mm (1/4 inch) in diameter and continue all the way upto 57mm (2 1/4) in diameter.

Most bars with relatively big diameters are deformed bars that is bars which have lugs or deformation rolled on the surface to provide anchorage in the concrete. The essential features of each of the current reinforcing bar specifications are given in Tables 1-6 as published by major producing companies.

PLAIN AND DEFORMED REINFORCEMENT BARS

TABLE 1: MECHANICAL PROPERTIES: Plain and Deformed reinforcement bars

PARAMETERS	DEFORMED BARS	PLAIN BARS
Tensile strength N/mm^2	High Yield oblique Ribbed 570-710	340-470
Yield strength N/mm^2	420 min	2335 min
Elongation %	14% min	24% min
180° Bending	2.5a	1a

a = diameter

TABLE 2: CHEMICAL COMPOSITION:Plain and Deformed reinforcement bars.

Steel grade	Colour code	Deoxidation Type	Laddle Analysis						
			Carbon C	Silicon Si	Manganese	Phosphorous	Sulphur	Copper	Nitrogen
NS 134-LC	Brown	k	0.06-0.12	0.18-0.28		0.40	0.040	0.025	0.010
NS 137-2	White	k	0.12-0.17	0.18-0.28		0.04	0.040	0.025	0.010
NSt 44-2	Yellow	k	0.14-0.20	0.18-0.28		0.40	0.040	0.025	0.010
NSt 50-2	Green	k	0.18-0.24	0.18-0.28		0.40	0.040	0.025	0.010
NSt 50-2	Half Green	k	0.25-0.34	0.18-0.28		0.40	0.040	0.025	0.010
NSt 60-2	Blue	k	0.35-0.42	0.15-0.25		0.40	0.040	0.025	0.010
NSt 60min	Half Blue	k	0.35-0.42	0.20-0.30		0.40	0.040	0.025	0.010
NSt 65min	Ble cross	k	0.28-0.35	0.20-0.30		0.40	0.040	0.025	0.010
NSt 70-2	Red	k	0.38-0.48	0.15-0.25		0.40	0.040	0.025	0.010

TABLE 3:UNIT WEIGHT AND BAR SIZES: Plain and Deformed reinforcement bars

Diameter (mm)	6	8	10	12	14	16	18	20	25	32	40
weight/metre (kg)	0.222	0.395	0.617	0.888	1.04	1.58	2.00	2.47	3.85	6.313	9.864
Pieces/Bundle plain bars, 9m	1000	562	360	250	184	141	111	90	58	35	23
Pieces/Bundle Deformed bars, 12m	750	422	270	188	138	105	**83**	67	**43**	26	17

TABLE 4:DIMENSION TOLERANCE: Plain and Deformed reinforcement bars.

Product Size	Tolerance	Ovality
5.5mm - 14mm dia	±0.4mm	0.56mm
16mm - 40mm dia	±0.5mm	0.70mm

TABLE 5: DIMENSIONS AND WEIGHT OF COILS

Profile	Diameter (mm)					
Plain Coil	5.5		6	8	10	12
Ribbed Coils			6	8	10	12
Outer Diameter (Bundle) (mm)	1250 - 1300					
Inner Diameter (mm)	650					
Coil Height (mm)	500 - 1350					
Weight (Kg)	1300 - 1500					

TABLE 6: HARD DRAWN WIRE SPECIFICATIONS

Annealed and Hard drawn	Diameter (mm)								
	5.0	4.5	4.0	3.5	3.2	3.0	2.8	2.5	1.6
Tolerance	+ 0.1mm							± 0.07 mm	
Tensile strength (hard-drawn N/mm^2)	600 - 900								
Tensile strength (Annealed) N/mm^2)	270 - 540								

Source: Hadassa Steel Rolling Company (1995) for tables 1 - 6.

2.5 Properties of Steels

Moore and Moore /26/ stated that a good structural engineer must have a clear understanding of what he call " the play of forces" in structures, that is, all the various forces or loads that are imposed on a structure. Secondly, the deformations caused, (or likely to be caused) by such imposed forces. In addition, the nature of reinforcement to be used in making such a structure stable.

Careful assessment of the various properties of constructional material will, undoubtedly reveal the nature of such material. Generally, the properties of construction materials, can be, broadly classified into:
(1) Physical (2) Chemical and (3) Mechanical.

1. Physical properties of materials include their characteristics relating to weight and density, permeability to liquid, gases, heat and radioactive rays as well as their resistance to environmental and atmospheric conditions.

2. Chemical Properties is the ability of material to withstand the action of acid, alkalis, salt solution and gases.

3. Mechanical properties are characterised by the ability of material to resist all external actions involving the application of force. This is by far the most important property as far as the use of steel reinforcement is concerned in the construction industry. The various mechanical properties comprise the following:
(A) Tenacity (B) Elasticity (C) Hardness (D) Toughness (E) Malleability (F) Ductility (G) Impact resistance (H) Rigidity. (I) weldability (J) Impact resistance (K) Rigidity (L) Strength (M) Creep resistance.

i. Elasticity and Plasticity

Material acted upon by external forces undergoes deformation. On removal of the forces it either recovers its shape completely, partially or not at all. Elasticity is that property which enables recovery of shape to take place. The intensity of deforming force is called stress and the initial deformation which occurs is called strain. The law of Elasticity states that stress and strain are directly proportional to each other during both loading and unloading, thus implying that complete recovery of shape takes place when the deforming forces are removed. No material obeys this law with absolute precision and various materials exhibit varying degrees of non-conformity with the law. In the case of steel, only high precision measurement will detect their departure from the law at stresses below what is called the limit of proportionality, a term which is supplanting the less precise elastic limit hitherto used. In general, other materials depart more or less widely from the law. Not only may non-proportionality between stress and strain be exhibited, but a residual deformation called permanent set may remain after loading. Plasticity may be looked upon as the absence of elasticity in the sense that plastic materials retains the impression made upon it by a deforming force.

When a ductile material is progressively stressed it first, goes through a phase where elasticity predominates,

and then passes in some cases - suddenly, in others gradually - into a phase where plastic behaviour predominates.

ii. **Tenacity**

This is the property which enables a substance to resist fracture under the action of tensile stress. In practice, it is expressed in newton per square metre of sectional area. The tenacity of any given material is ascertained by actual experiment in the testing machine a specimen of known dimensions being pulled and the load noted. The tenacity of metal is considerably affected by the presence of impurities, by mechanical treatment, as in forging and rolling, and by variation in temperature. A consideration of the strength of materials is not limited to the action of tensile stress, but must also include compression or crushing stress, shear, bending and torsion /30,32/.

iii. **Strength**

This may be defined as the resistance to yielding or breaking which a material opposes to a force acting on it, and can be determined only by experiment. It should be noted that hardness is also one kind of strength as Hertz and clerk maxwell /32/ agreed in considering it. Although they differed as to what particular strength it was /32/.

iv. **Rigidity**

This is that quality by virtue of which a material resists change of form when subjected to the action of

external forces. The magnitude of young modulus in tension or the corresponding ratio of stress to strain in shear (modulus of rigidity or shear modulus) are measures of the rigidity of the materials /32/.

v. **Ductility**

Is the quality possessed by material which show considerable plastic deformation before breaking and can be measured by the ultimate percentage elongation and reduction of area before fracture in a tensile test, or by the angular deflection before fracture in a bend test. The quality of toughness is sometimes defined in a similar manner but, as it will be explained the two are definitely distinguishable from each other.

vi **Brittleness and Toughness**

Brittleness can be defined in various ways it is obviously the quality possessed by materials which break suddenly, with little, previous deformation, when loaded progressively. It must not be confused with lack of strength , for some brittle materials, as many varieties of cast iron, have a comparatively high tensile strength. It is also used to express that quality of a material characterized by a low value in a notched bar test. Notch-value (toughness or brittleness) is a measure of the resistance of a material to fracture when subjected to flexural impact in a region where a high local stress is produced at a discontinuity. Low notched-bar values may be shown by materials of good ductility. Ductile steel may

thus be either notch-tough or notch-brittle. Toughness is a term used very loosely to denote several distinct qualities: strength, ductility or notch-toughness. It seems therefore desirable to restrict the term to another usage, that expressing a suitable combination of strength and ductility. Thus very strong steels have usually a relatively low ductility; and very ductile steels a relatively low strength. A "tough" material is one in which the amount of permanent deformation is sufficient to increase the strength to a maximum; but is not so much as to reduce the ductility unduly.

vii Hardness

This may be defined, very broadly, as that quality of a material by virtue of which it resists the local displacement or removal of portions of its substances. Is a complex property of a material, and the term maybe used in several senses. It cannot be adequately defined without specifying the particular type of hardness implied. It may mean resistance to penetrations; or penetrative power. It may mean ability to scratch other bodies, or susceptibility to be scratched by them. It may mean resistance to rolling abrasion or to sliding abrasion. It may mean resistance to elastic deformation.

viii Malleability

It is the property which enable a body to be extended in all direction by hammering or rolling. The degree of malleability is gauge by the thinness of the leaf or foil

which it is possible to produce. Gold is the most malleable of all metals. Malleability depends partly on hardness and partly upon tenacity, and is much affected by the presence of impurities and by temperature.

ix. Impact resistance

Another property of a material bearing no direct relation to its standard properties, yet of great practical importance in engineering, is its capacity to withstand shock or impact.

x. Fatigue resistance

It has been known for many years that cyclically loaded materials will eventually fail at stresses the maximum values of which only reach a fractional part of the ultimate static stresses which the materials are capable of withstanding. Experiment shows that if the peak stress of a given mode of cyclical loading is kept below a certain value the endurance of the material proves to be for all practical purposes unlimited. Such stress is termed the fatigue limit of the material for that particular cycle and bears no discoverable relation to the standard physical properties of the material. The phenomenon which results in failure of this limit is exceeded is known as fatigue.

xi. Creep resistance

It was recognised many years ago that both the standard and the more complex physical properties of materials were considerably modified when they were subjected to elevated or depressed temperatures. Much

experimental work was devoted to the quantitative determination of these temperature effects and the results were made more or less generally available. It was not until Dickeson in 1922 /32/ and Lea in 1924 /32/ published the results of their researches, however, that attention was drawn to the phenomenon of creep in materials when stressed at high temperatures. Creep may be looked upon as a continuous plastic yielding under a constant stress. The rate of creep is exceedingly low when compared with the rate at which ordinary yield takes place. Creep also occur without a stress.

xii. Creep

Mosley and Bungey /24/ defines creep as the continuous deformation of a member under sustained load. In other words, it is a time depended deformation with or without load. It is phenomenon associated with many materials including steel. Mosley and Bungey /24/ noted that this phenomenon is particularly evident with concrete; and that, the precise behaviour of a particular concrete depends on the aggregates, the mix design and strength.

It is important to steel reinforcement because when a structure (reinforced concrete structure) is subjected to load, there is a redistribution of load between the concrete and any steel present /24/. This is caused by changes in compressive strains being transferred to the reinforcing steel. Other characteristic of creep include:-

1. The final deformation of the member can be three to four times the short term elastic deformation.
2. The deformation is roughly proportional to the intensity of loading and to the inverse of the concrete strength.
3. If the load is removed, only the instantaneous elastic deformation will recover-the plastic deformation will not.

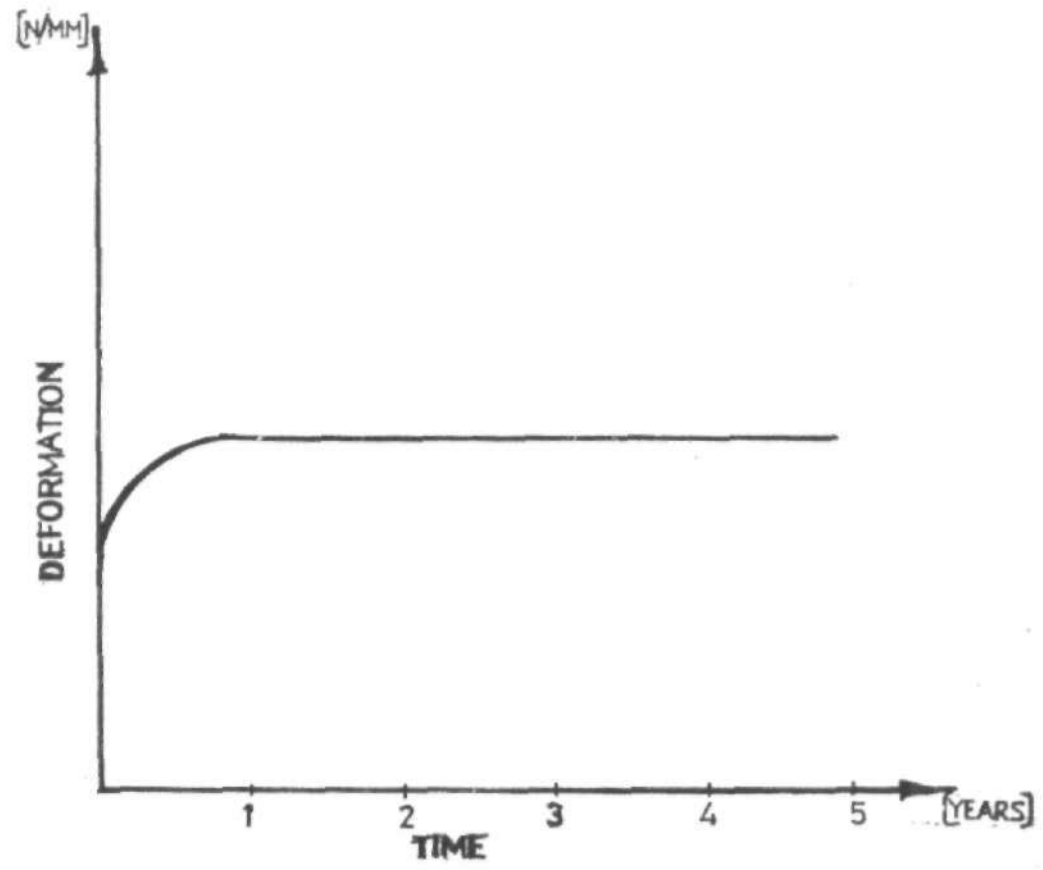


Fig. 1: Time-dependent Creep

The effect of creep are particularly important in beams, where the increased deflections may cause the opening of cracks, damage finishes, and the non-alignment

of mechanical equipment. Redistribution of stress between concrete and steel occurs primarily in the uncracked compressive areas and has little effect on the tension reinforcement other than reducing shrinkage stresses in some instances. The provision of reinforcement in the compressive zone of a flexural member, however, often helps to restrain the deflections due to creep.

Apart from the time-depended creep, there is another one associated with temperature. When a steel is stressed at temperature over and about 300°c, it no longer behaves elastically, but shows a very slow plastic flow or "creep", continuing to extend in length even under comparatively small loads as may lead ultimately to fracture. While creep is shown by steels at temperatures over about 300°c, it may became pronounced at those temperature for carbon steel.

The creep properties of steel vary with their composition, the melting and de-oxidizing conditions used in their manufacture, the presence of soluble and insoluble impurities, the degree of hot or cold reduction by working, the heat treatment and resulting variation in grain size and microstructure, the phase changes, and recrystallization effects and so forth.

Creep Testing

The basis of creep testing is to subject the specimen to a given load at a given temperature and measure its elongation

under load. This may be carried out for a certain length of time, or until fracture occurs. In this way deformation-time curve is obtained as in figure 2 showing in general three stages. The primary stage, of fairly short duration, shows a rapid but diminishing strain.

The secondary stage shows a relatively small strain; which may continue at a fairly constant rate for a very long period. The creep rate for a given stress is that determined during this secondary stage, the test being usually terminated when this rate has been established. It should be noted, however, that while two steels may show similar creep rates at the end of particular test period their, total deformation may vary considerably, depending upon the shapes of the time-deformation curves in the early stages of the test. During the process of secondary creep if the load is removed and the temperature is maintained, some of the deformation recovered. If sometime the temperature falls, recovery will be reduced or prevented.

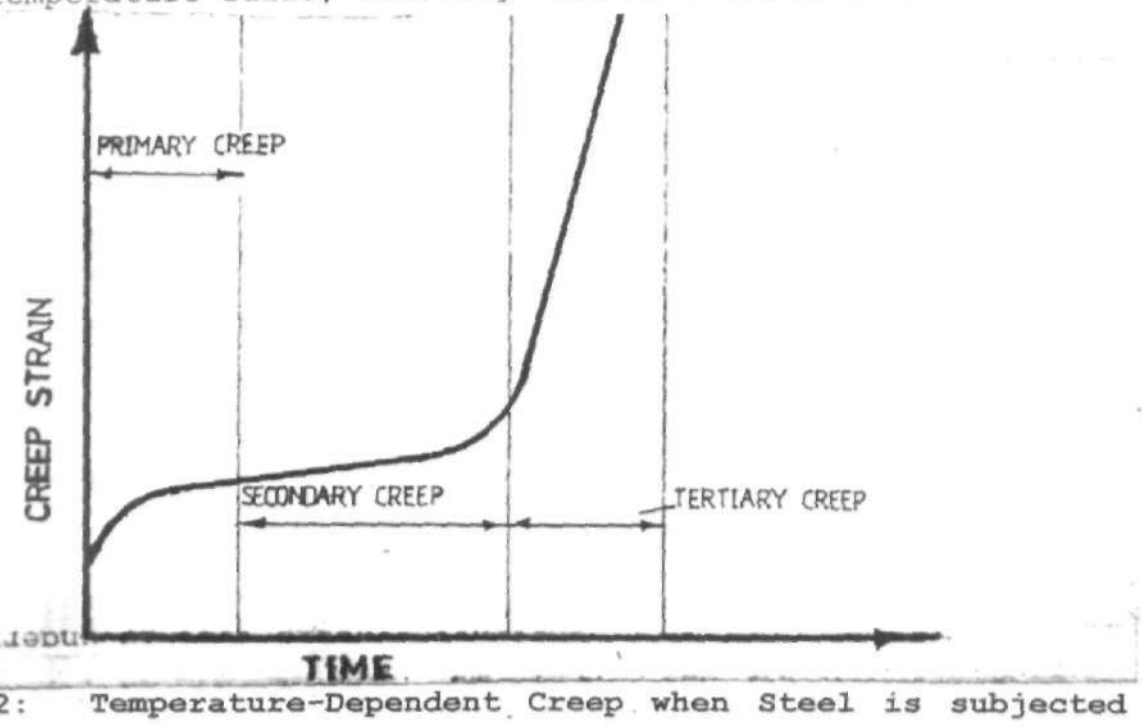


Fig. 2: Temperature-Dependent Creep when Steel is subjected to Heat over 300°c.

2.5.1 Effect of the chemical composition on the quality of steel

The properties of steel is largely a function of the various chemical constituents present in it. Most especially carbon, which is by far, the most important element in steel, and as the content of carbon increases, up to about 0.90 percent, its response to heat treatment and its depth of hardening increases.

In the "as rolled" condition increasing the carbon content increase the hardness, strength and abrasion resistance of steel but decreases the ductility, impact properties and machinability /32/.

Rolfe /32/ in explaining the relationship between carbon content, strength and ductility contended that the approximate tensile strength of any normal steel can be determined even more readily from the carbon content. He further evolve an extremely simple formula, based on carbon content, for the calculation of tensile strength and elongation a geometrical calculation gives us the empirical formula /32/.

$$y = (93x + 41)/2 \qquad (1)$$

where x= carbon content percent and y= tensile strength in N/mm_2

A similar calculation for the elongation relationship gives: /32/:

$$Z = 43.7 - 64.5x \qquad (2)$$

where x = carbon content percent and z = Elongation in percent.

Apart from the carbon,there are other, important alloying elements that effect steel quantities.

A. **Aluminum**: The major use of aluminum in steel making is as a deoxidizer, often in conjunction with other deoxidizing agents. It restricts and control grain growth.

B. **Chromium**: Chromium contributes to the heat treatment of steel by increasing strength and hardness. It increase resistance to both corrosion and abrasion. Chromium steels maintain their strength at high temperatures

C. **Columbium**: It is used in carbon steel to develop higher tensile properties. It also combines with carbon to provide better corrosion resistance and is often used for this purpose in stainless steels.

D. **Manganese**: By its chemical action with sulphur and oxygen, manganese makes it possible to roll hot steel and is therefore next in importance to carbon as an alloying element. It has a strengthening effect on iron and increases the machinability of machining steels but tends to decrease the ductility of low carbon drawing steels.

E. **Molybdenum**: It raises the temperature at which steel coarsens and promotes its ability to harden. It increases the high temperature strength of steel, improves its resistance to creep, and improves the corrosion resistance of stainless steels.

F. **Nickel**: This improves the ability of steel to harden and increase its toughness after tempering. It is particularly useful in strengthening unhardened steels and improving impact strength at low temperatures. It is used in

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conjunction with chromium in stainless steels.

G. **Phosphorus:** It strengthens steel but reduces its ductility. It improves the machinability of steels with high sulphur content and, under some conditions, may help to increase corrosion resistance.

H. **Silicon:** Is one of the main steel oxidizer and is commonly added to steel for this purpose. In amounts up to about 2.5 percent, it increases the ability of steel to harden. In lower carbon electrical steels, silicon is used to promote the crystal structure desired in annealed sheets.

I. **Sulphur:** Sulphur added to steel increase it machinability but decrease the ductility of low carbon drawing steel. It detrimental effect in hot rolling is offset by manganese.

J. **Titanium:** It is used in stainless steels for stabilization by holding the carbon in combination. It is also used for special single coat enameling steels. In low carbon steels, its use, in conjunction with other alloys, promotes fine grain structure and improves the strength of the steel in the "as-rolled" condition. /33/

K. **Vanadium:** Is a mild deoxidizing agent. It promotes strength at high temperature and has good response to heat treatment. It is useful in strengthening an unhardened steel. Vanadium steels have improved fatigue value.

2.5.2 Behaviour of steel under loading

The behaviour of steel under loading could be well appreciated, if the theory of elasticity is examined. As far back as 1676

Thomas Hooke /32/, writing on "the true theory of elasticity" deduced the law that "as the stretching is, so is the strength" or as it may now be expressed, within the elastic limit, strain is directly proportional to stress. That is, when mild steel specimen, is subjected to tension (testing) it will not show any signs of dimensional alteration during the early loading. As it is gradually increased, the strain is for sometime proportional to the stress, the graph assuming the form of a straight line, representing the period during which the steel is stretching elastically, when the load is taken off, the gauge returns to its original dimension. This continues up to a point known as elastic limit. If, however, the piece is stress beyond its elastic limit stress it will not regain its original size or shape when the deforming force producing the stress is removed. This region is called the plastic stage and there will be dimensional change which persist after all load is removed so that it will be what is knows as permanent set. If the loading persist, a well defined yield point (as shown in figure 3), point in region Y, manifest itself at Y where there is a considerable extension without increase of load. After passing the yield point the extension is partly plastic and partly elastic, increasing with increase of load as the sometime its cross-sectional area is being reduced when the maximum stress is attained, the extension is purely plastic. At this stage,, there is a rapid extension and a corresponding "necking-down" leading finally to fracture, at one position in the test piece.

If, in a similar test, an autographic record is made it will be found that the yield point really occurs in two stages. Upper and lower yield point. The magnitude of the upper in relation to the lower yield point is very variable, depending on many factors. Docherty and Thorne /9/ gave a large number of comparative values for Armco iron and a variety of steels using different types of test bar. It was observed that the upper yield point varies in value with the degree of surface finish, the shape of the test piece (particularly the degree of change of section)and the rate of loading.

The lower yield point is that determined in the usual commercial test and chiefly used in design calculations. Rolfe /32/ contended that under dynamic as compared with static loading mild steel shows a yield point some 20-40 percent greater than the static value, a higher tensile strength and increased energy to cause fracture.

The "true stress-true strain" diagram has received considerable attention, on the ground that it should afford much more fundamental information about the properties of the materials and thus constitute a better guide to service performance. It must be appreciated, however, that even the "true stress-true strain" diagram is true only to an approximate degree.

The fundamental character of the true-stress-true-strain diagram has been advocated in two papers by Vivian and O'Neill /32/ in which it is regarded not only as constituting a simple measure of the work-hardening characteristics of the material, but also a complete representation of all mechanical properties

of the elementary kind. Again, Voce /32/ advised that no tensile test were to be conducted in future without determining the true-stress-and true strain at the maximum load or necking point.

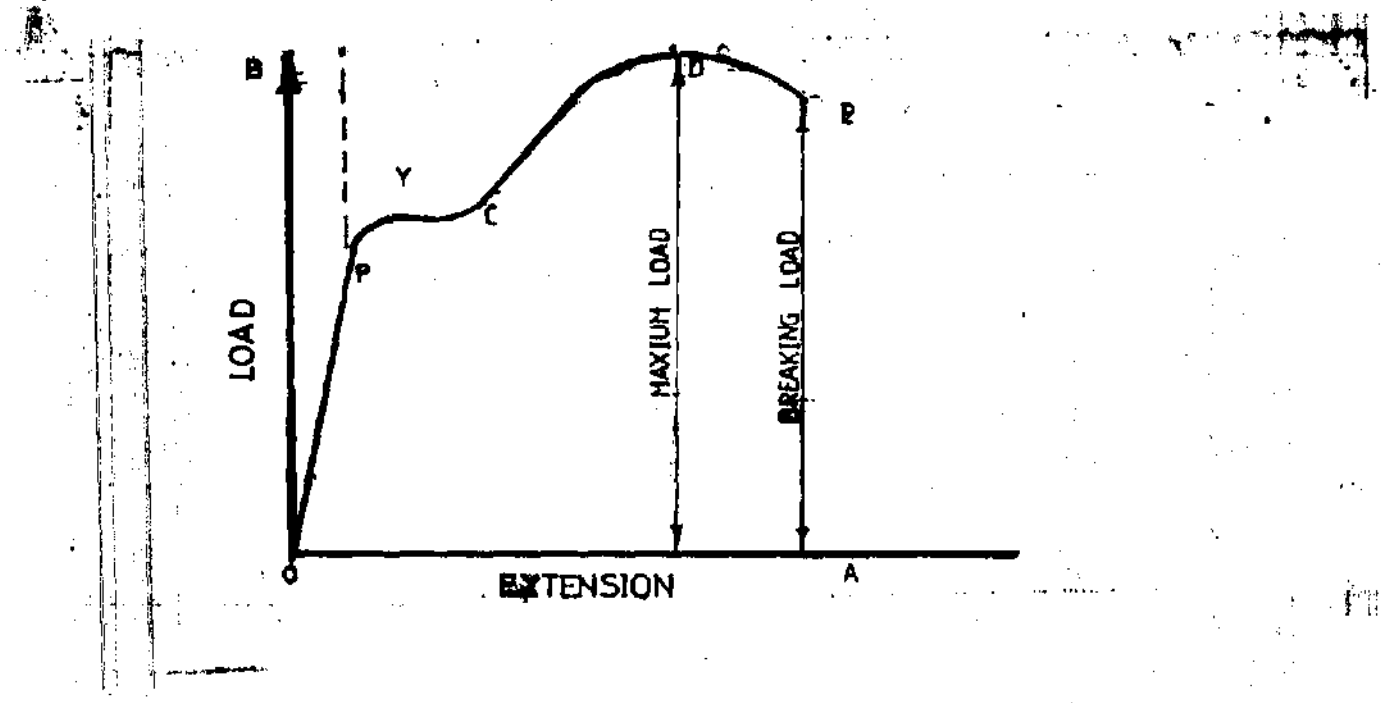


Fig. 3: Load-Extension diagram (Mild Steel)

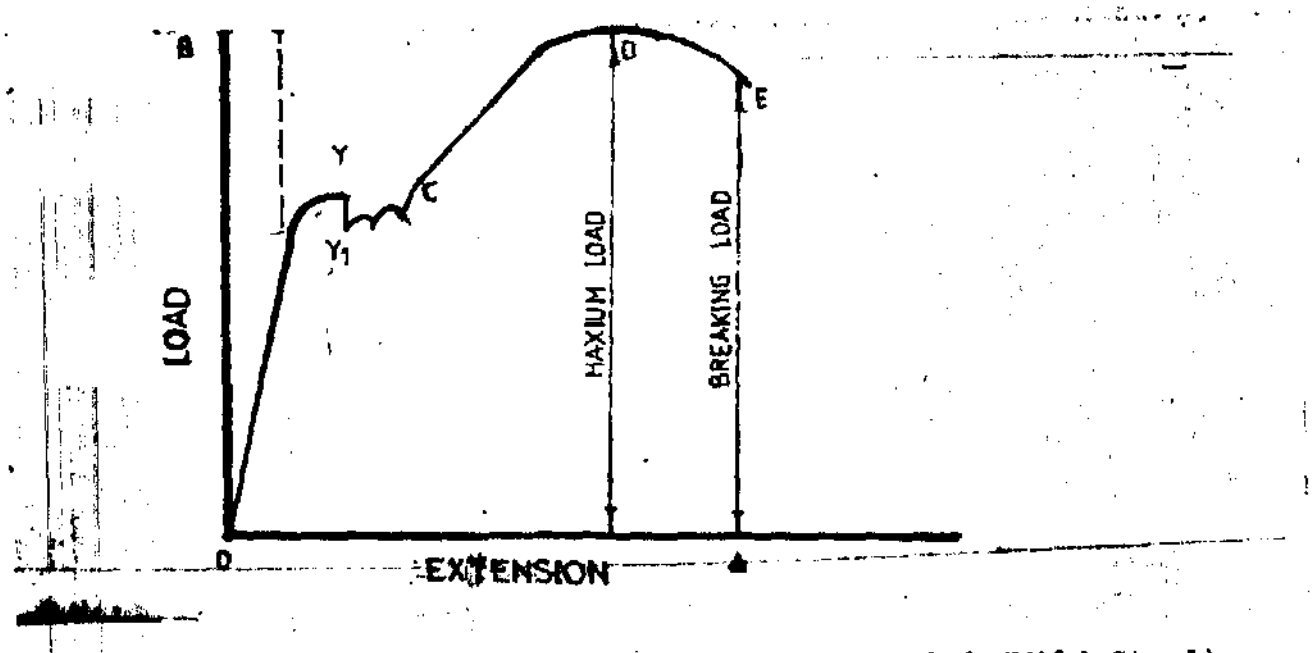


Fig. 4: Load-Extension Autographically Recorded (Mild Steel)

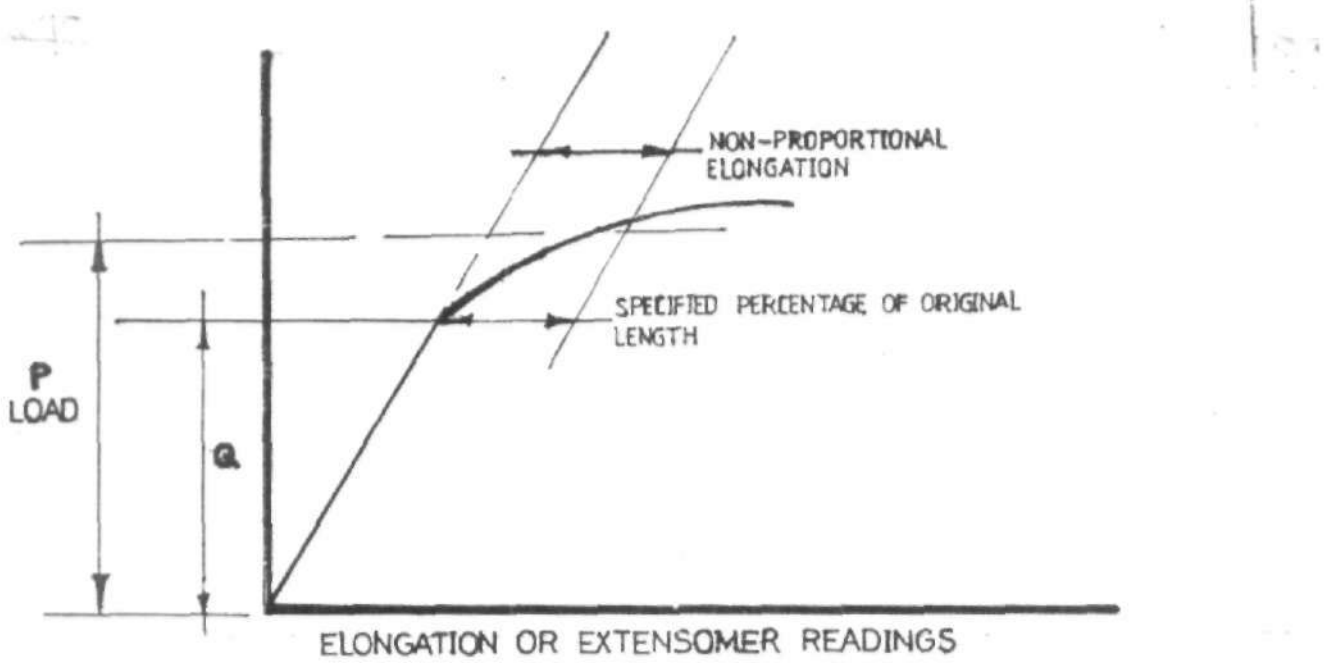


Fig. 5: Load-Extension with No Yield Point for Non-ductil Material

2.5.3 Metallic Bond

Metallic materials are composed of large aggregates of atoms. Within an aggregate the individual atoms are bounded together in someway. Individual atoms normally have completely filled outer electron-sheet, but in combination with other atoms there is an attempt to obtain the filled electron shells necessary for stability. There are several types of bonding possible and these can be categorized as primary bonds and secondary bonds. Primary bonds are the bonds that exist between atoms. Secondary bond which are less strong than the various primary types may exist between molecules. The primary bond types are the ionic bond, the covalent bonds and the metallic bond.

To understand the macroscopic properties of metals and alloys in any detail, some knowledge of the metallic state at the atomic level is necessary. All the properties of metals under stress may be accurately explained by the interactions occurring microscopically. Indeed, it is the knowledge of physics involved between individual atoms and groups of atoms that allow predictions of all physical behaviour to be made. The ability to which one can relate actual tests with known atomic structure will mark the extent to which one can make correct decision in selection of metal for a given design. Such ability is only possible through an understanding of the way in which metallic properties correlate to their metallic state.

Metallic Bond

In a pure metal or alloy each atom is independent of its neighbours i.e., there is no definable molecules. The valence electrons of each atom exist in an unconfined state, free to move randomly among the other atoms at a very high velocity. This is because of nearly equal energy levels existing on the valence sheet of the atoms in lattice. Thus electrons may move from one atom to the next without disrupting the electronic equilibrium of the structure. The aggregation of all free valence electrons is called electron cloud, a peculiar property of the metallic state. The freedom of electrons from individual atom is responsible for the unique elastic behavior of metals.

When the atoms in a metal give up their valence electrons to the electron cloud, in metallic bonding, they become positive

ions, held in position due to their attraction to the electron cloud and their mutual repulsion. For an equilibrium to exist in the structure, these forces must act in such a way that the resultant is zero. At some specific atomic spacing, a level of lowest energy is attained, for which internal forces cancel each other. The structure will seek to reach this equilibrium position if displaced, given rise to the elastic behaviour of metals in tension and compression. The graph below shows the internal force against distance for two ions.

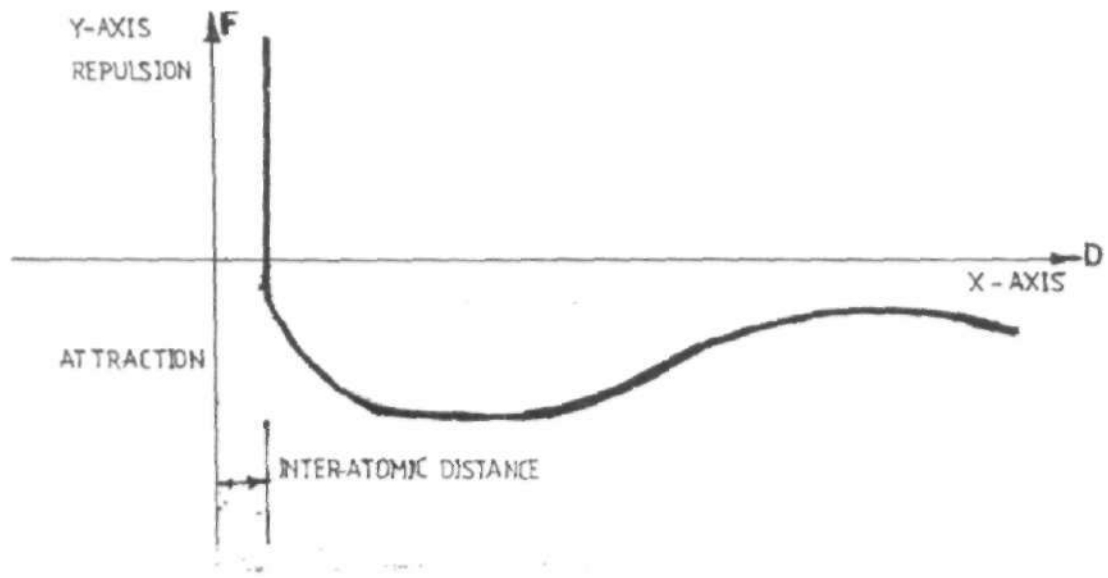


Fig. 6: The Internal Force Against Distance for Two Ions.

Point above the x-axis correspond to repulsive force while those below the x-axis correspond to attraction (i.e forces of attraction) and where the curve cuts the axis indicate the equilibrium spacing or mean interatomic distance. If the structure (metal) is under tension, it implies an attempt to increase the interatomic spacing and the attractive force predominates, resisting the deformation and restoring the equilibrium position after the load is removed.

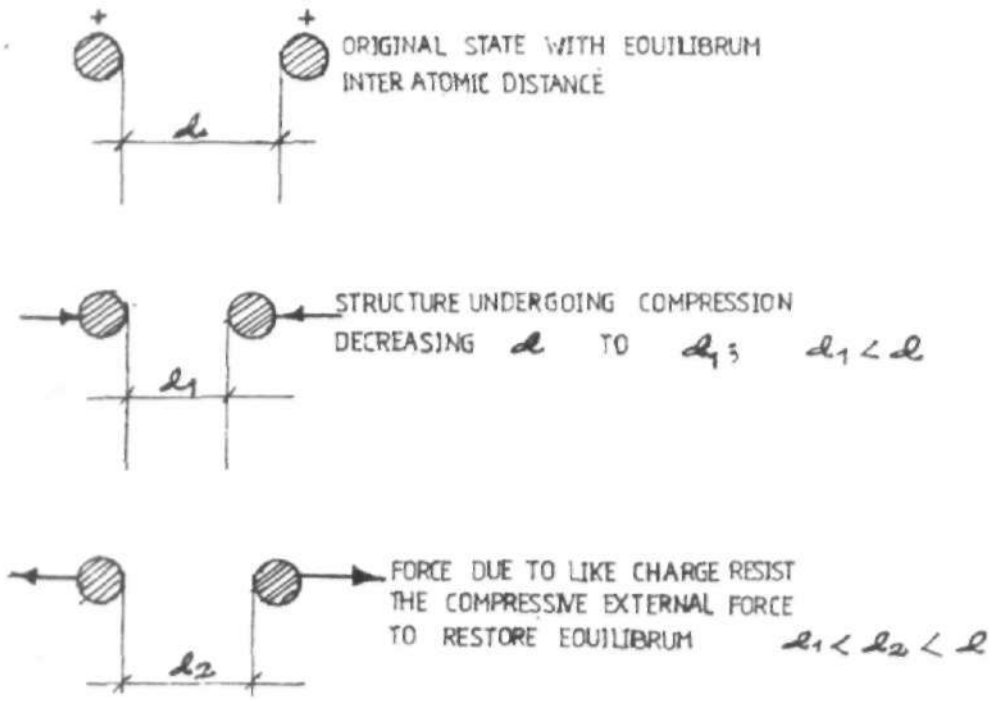


Fig. 7: The Metal Under Tension

In the same way, when compressive forces are applied, the ions are pushed very close together, and the repulsive forces due to their like charges resist the deformation, again

restoring the lattice to its equilibrium spacing when load is removed.

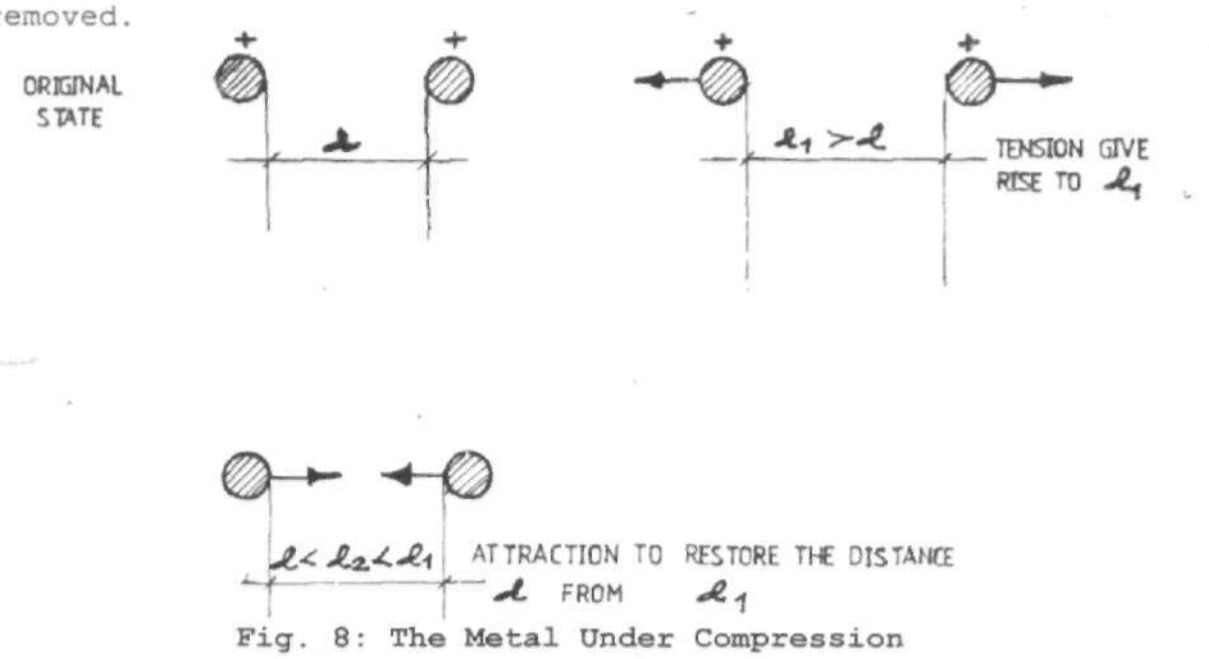


Fig. 8: The Metal Under Compression

For an equilibrium to exist throughout the structure in the absence of any external or internal forces, the interatomic distance must be the same for all atoms in the lattice. Each metal or alloy is associated with a unique interatomic distance which allows individuals metals or alloys to be identified. This is done through their characteristic x-ray diffraction pattern. This pattern is as a result of the crystal structure and atomic spacing thus possessing the same uniqueness as the inter atomic distance of an individual metal.

It is important to realize that it is perfectly normal for any and every structure to deflect in response to a load. This is an essential characteristic without which no structure can bear and transmit load. Although every kind of solid changes its shapes to some extent when a weight or other mechanical force is applied to it, the deflections which occur in practice vary

enormously. It is affected both by size and geometrical shape and also by the sort of material from which it is made. Material vary very greatly in their intrinsic stiffness.

When we put ordinary load on hard substances like metal the deflection is very small to see with naked eye, they always exist and are perfectly real, even though we may need special appliances in order to measure them. Hooke/9/ said when any structure deflects under load in the way mentioned above, the material from which it is made itself also stretched or contracted, internally, throughout all its parts and in due proportion, down to a very fine scale to a molecular scale.

The chemical bonds which join the atoms to each other, and so hold the solid together are very strong and stiff indeed. So when material as a whole is stretched or compressed this can only be done by stretching or compressing many millions of strong chemical bonds which vigorously resist being deformed, even to a very small extent. Thus these bonds produce the required large forces of reaction.

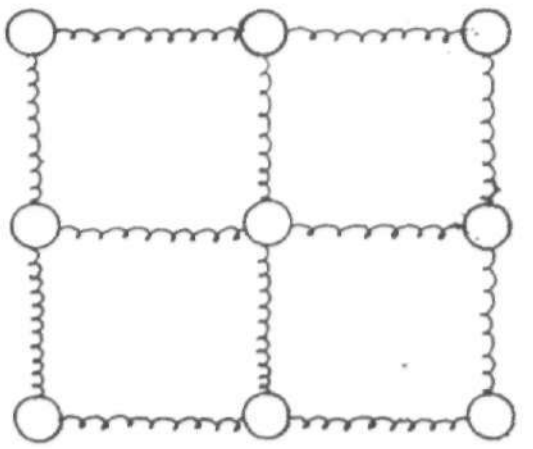


Fig. 9: Neutral, Relaxed or Strained-Free Position

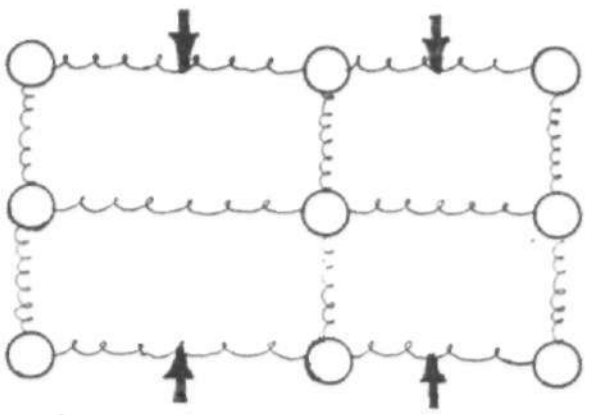


Fig. 10: Material Strained in Compression: Atoms Closer together and Material gets Shorter.

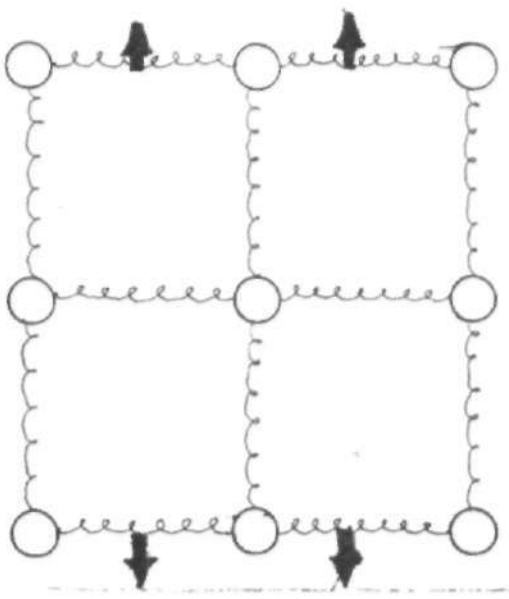


Fig. 11: Material Strained in Tension, Atoms are further apart and Material gets Longer

2.5.4 Test done to determine properties of steel

There are various test used to assess the desirable qualities of steel, so that the suitability of the material for its intended purpose, or perhaps the reasons for its premature failure, being deduced from, the results of many different experiments.

Rolfe/32/ asserted that tensile test has been considered the standard test for parts whose strength is important, for in this test, the strength is determined in exact units of Newton, per square millimetres and it is in similar values that the designer computes the stresses existing in the various parts in service.

All test are done in accordance to the appropriate British standard. For instance tensile test is undertaken according to the provision of BS 4449 and BS 18 part 2. While Bend test is done in accordance to BS 32, BS 4449 and BS 1639.

2.6.0 Steel in Nigeria

Planning of steel industry in Nigeria can be traced back to the pre-independence era. That was in year 1958/29/. When the then federal government indicated strong interest in the establishment of steel industry. Initial steps taken towards this end, include feasibility studies aimed at establishing steel rolling mill and the exploration of steel market /29,27/. But with discovery of coal and iron ore in Agbaja (Kwara state), Udi (Anambra state) and other parts of the country, coupled with the proposal to construct the hydron-electric Dam at Kainji led

to change of mind and plan were made to build an integrated iron and steel plant (i.e with a complete production cycle). /29/.

In the period of 1960 to 1967, the federal government invited and received several proposal from foreign firms in the United states, West Germany, Great Britain and Canada to build such plants. However, all these proposal were based on using Agbaja and Udi iron ores deposits using Direct Reduction Process-that is, making steel without the blast furnace process of making pig iron as an intermediate product.

The discovery of oil and gas in Nigeria on larger scale re-awakened and boosted the establishment of a direct reduction steel plant in the country.

In 1967 a team of soviet expert were invited to conduct a feasibility study for setting up an iron and steel plant, and they recommended a blast furnace process but their report indicated that further investigation was required with regard to locating better quality ores and coal and this was subsequently carried out. Feasibility studies went further and were, even, conducted outside Nigeria. High quality iron ore were found and exploited in Liberia, Guinea and Brazil. Limestone of acceptable quality was found in Mfamosing (Cross-river state). In 1968 such survey were concluded and coal deposits exist in Nigeria. Based on the findings from the feasibility studies; in 1970, the U.S.S.R signed a contract with Nigeria to send specialist and ship equipment to Nigeria for further geological surveys to determine the quality and quantity of iron ore and coal suitable for use at the future steel plant.

2.6.1 Steel demand in Nigeria.

CHAPTER THREE

FIELD SURVEY

3.1 Preamble

published by the company, information Handbook on the company and operation manual of the company.

3.2 *Genesis of Hadassa steel company*

Hadassa steel rolling company is one of the three inland rolling mills established by the Federal Government. The contract agreement for the construction of the rolling mill on tunkey basis was signed between the federal government of Nigeria and foreign company on the 8th June, 1979. The foundation stone was laid on Thursday 16th, April 1981 while in September 1982 the reheating furnace began operation and the preliminary acceptance test of all equipment was completed and commercial production commenced in the same month. Later, the plant was officially commissioned in December, 1982.

One of the objectives of establishing this company is to serve as an avenue for technology transfer and as part of the effort of federal government of Nigeria to be counted among the steel producing nations.

The mill was planned to have production capacity of 210,000 tonnes per year, on 2-shift operation, based on specified product mix of reinforcement bars and wire rods. The capacity was expected to expand to 420,000 tons per annum at the second stage and 720,000 tons/year at the third stage. Both the second and third stage was planned to be undertaken on 3-shift operation. The major civil structures for the second stage were laid along with the first stage to minimize interference with production line while erecting the second stage.

The company has five hundred and sixty-eight (568) members of staff with the General Manager as the head and chief executive of the rolling company. He is also a member of the board of directors, a body which is normally appointed by the Minister of Mines, Power and Steel. The board of directors see to the overall affairs of the company and it also, feed the federal government with information on firm's transactions.

For effective and efficient management the company is divided into six departments. Each of these departments has a manager who reports to the General Manager. These departments are as follows:

A. Administration Department including GM's office 176 staff
B. Mintenance and technical service department 193 staff
C. Production Department 1651 staff
D. Commercial Department 17 staff
E. Financial Department 9 staff
F. Corporate Planning 12 staff

Total **568 staff**

3.3 Production Process

The production aspect is essentially rolling of steel into different forms and sizes. Steel rolling is the process of plastic deformation of metal between two or more rotating rolls; this can be affected by various methods. In other words it is the process by which simple solid sections of steel bars or coiled are produced in various shapes i.e round, hexagonal, square, etc.

To accomplish this task, raw materials in form of billets are received-mainly from the Delta steel company at Aladja. This billet classified by steel grades, heat number, weight and dimension; is a long piece of steel product weighing up to 1.3 tons each is received in billet receiving yard. In a typical production day, the billet is then conveyed from the billet receiving yard with the aid of an overhead crane to the billet receiving table. At the billet receiving table it is fed into the reheating furnace with the aid of the A.C Auxiliary motors operating both the Run-in- rollers and the pusher. The furnace with the capacity of about 100 tons/hour, is oil fired and maintain a temperature range 1000c°c. The billets are heated to certain temperature depending on the steel grade and desired product size. The billet inside the furnace having attained this final temperature of 1000°c or thereabout (as the case may be) is pushed out from the reheating furnace with the transformation journey to either wire-rod or Bar of various sizes. The process of rolling the billet physically is done within the 3-main mill-strains. That, is the Rolling mill, the intermediate mill and the finishing mill train. Each of this mill train is composed of some DC monitors plus some rolling stands.

For the production of Bars (with ranges from 12m -40mm diameter) the billets passed through the Rolling mill then the intermediate mill and finally the finishing mill train before being sent to the cooling bed. During the process of rolling the rolled product is cut into determined lengths by the

dividing shear and finally cut to the customers requirement by a cold shear.

For the production of wire rod the rolled product escaping from the 3- main trains is further passed through a Block mill which effects the final reduction to the finishing diameter (between 6.0mm-12.0mm diameter) laying head is used to coil the product which is then air cooled in the conveyor to the coil forming stations. The wire Rod is carried to the binding machine by small loop hook conveyors where it is compacted and bound in a finished form.

The production of 10mm bar and 5.5mm diameter wire rods was not in original product-mix but was locally developed in response to market demand. Normally, the raw material used, that is, the billets -are delivered from Delta steel company DSC or imported; and so the mix is done in accordance to the Hadassa steel rolling company specification.

I Machinery

The machines which made the mill outstanding in production are:- Reheating furnace, main motors, for drawing the rolls, crop and cable shear , dividing shear, Rolls in Rollers cooling shear, Regular traverser , Run out Roller, Cold shear, regulator product receiving table,, Bundling machine, overhead crane and transfer car.

ii. Improvements in the machines

Right from the time the company was established to date there is marked improvement in the machine installed. These are as follows:

1. Double strand rolling facilities
2. Wire drawing plant.
3. Captive power plant
4. Straightening
5. Mechanical loading system

These additional facilities have helped in raising the production capacity of the company and also extended the scope of its product mix.

The double strand rolling facilities aids to increase production as two billets could be rolled simultaneously instead of only one. No other rolling mill in this country has such production device. While straightening facilities make it possible for products that can be produces directly only in coil form to be straightened into bars to meet customers demand. In order to satisfy the raw material needs of down stream wire processing industries, a wire drawing plant was constructed which produces hard drawn and annealed wire of 1.0-5.0mm with installed capacity of 8,600 tons per annum.

There is also an improvement in the production of 10mm bar,so that instead of using/following the conventional method of producing it in the wire rod form and later straightening it, it is produced directly on the cooling bed. This helped in reducing the production cost and increased the production

capacity of this product dimension.

iii. Power supply

The Hadassa steel rolling company power consumption is adequately provided for by the NEPA. The mill with an initial power consumption of 12.5 million. WATTS is supplied from 30MVA NEPA substation situated a short distance from the receiving station of the mill.

In order to avoid the attendant problems of being wholly dependent on NEPA for power supply, the company acquired an electric power plant consisting of 3x9 MVA and 1x1, 176.6 KVA generators. The plant was commissioned in March, 1984. The plant is normally operated during production hours whereas power from NEPA supports the furnace and other auxiliary facilities at other times. The power plant has a provision for a fourth engine to increase the installed generating capacity to 36 MVA.

iv. Water supply

Water is very important consumable in the process of steel production. since the machines in contact with the 'HOT METAL' get heated up and adequate provision must be made for their cooling in order to maintain their optimum working condition. Also the 'HOT METAl, needs to be systematically cooled to maintain a good finished product hence the need for adequate water supply in a steel plant.

In this respect the Hadassa steel rolling company has a water reservoir capable of supplying its own water requirement. Attendant to this question of water supply is the provision of water treatment plant since the water used in the mill is re-

circulated hence the need to preserve its quality. In this respect the plant has a cooling system which ensures that the re-circulated water from the factory is properly cooled to its ambient temperature, then filtered and then sent to the reservoir for continued circulations.

3.4 Quality Control

Hadassa steel rolling company like any other steel industry has a vital unit-the quality control unit- that examines or rather determines the extent to which the steel product is being produced in accordance to the specifications. This unit is under the maintenance and technical services department. The quality control activities in this company could be classified as:

1. Quality of Design or/ Manufacture and
2. Quality of conformance/ Analytical quality control. /5/.

1. Quality of design/ manufacture

This is a quality control of concept and specification, which characterizes the precision (accuracy) with which products are produced. For example, from Roll-cutting (calibre design) to actual rolling operation. In other words, this is a structural or dimensional quality control. This is normally found along the production line (on-line). This responsibility naturally falls on the "Rolling team:. They are concerned with dimensional analysis and structural verification e.g. size, quality and other physical defects such as overlaps, rough

surface scale marks, roll marks rolled in extraneous matters etc.

2. Analytical control or/Quality of conformance

This involves a systematic and careful analysis (chemical or mechanical), mainly consisting of testing and inspection of incoming raw materials, semi -finished and finished products. This is where the "quality control lab" comes in. It has to device a suitable analytical methods for determining the content of ingredients (in this case, the chemical element in steel) impurities, etc; and method for determining certain properties such as strength, hardness, purity and other characteristics. Various tests are also conducted on the cooling and portable water used in the factory. Not leaving out the analysis of the types of oil used on the machineries:- determining their condition for use or otherwise.

In order to really understand the quality control, they can be divided into three stages /27/ A. Control before rolling B. Control during production C. Quality control after rolling.

A. Control before rolling:

When the material purchased arrives the company, an acceptance inspection is usually conducted by the billet handling group. This involves visual inspection to ensure that the specification, appearance and colour code requirements are met. The characters that are inspected on, include: steel grade, heat number, weight, surface deflects and correct colour code. The instruments used in carrying out this inspection are

scale and gauge. The measurement is done by 100% sampling.

Also in the billet yard, the group (billet handling) sees that correct weight of billets are maintained and proper stacking affected. These activities are usually done per delivery. The next step is choosing the right type of steel grade to suit customers need. The suitable steel grade is chosen for a particular product. For example, when coils are to be produced, Ns 34 LC, RST 34-2, RST 37-2 Or ST44-2 (on rare occasions) are used with respect to their carbon content; on the other hand, if stronger bars plain or cross ribbed are required the choice of steel grade will be ST 60-2

B. Control during rolling:

The activities here take place at the re-heating furnace and are taking care of, by the reheating group. They continuously monitor the temperature at each of the three zones of the furnace as well as the pressure inside the furnace.

During rolling process, the items that are controlled include the passline, roll gaps, entry and exit guides, cropping length tension and loop. Quality characteristics requirement are properly alignment of passline, adjustment of the roll-gaps, setting of entry and exit guides, cutting of top and bottom, and finally setting the correct motor speeds. The use of gauges, verniers, and steel rulers are employed by the rolling groups in carrying out their jobs. The aim of the foregoing activities being done is to achieve the desired shapes and sizes, and to control the diameter along the length.

C. Control after rolling

When the finished product comes out, a hot saw cuts a section of about 0.5m. This is sent to the quality control laboratory for accurate measurements of weight, diameter, length, straightness and surface appearance is checked, also, to ensure that the product is free from surface and internal defects, scales, verniers, micrometers, sensors, reagent handling equipment are the instrument used by the laboratory group in performing these activities twice per every heat number. The measuring method involved is the use of sampling control charts.

After these measurements, depending on whether the product met the required specifications, the rolling group are ordered accordingly. That is, if it met the required specifications, they would be given the "go-ahead" order; if not, they are ordered to continue adjusting until the necessary corrections are effected.

The sample is then tested for mechanical properties this involves subjecting it to some test such as tensile testing to ascertain whether the material meets the parameters as contained in the specifications prepared by the company. For example if the company intends producing plain bars but on testing the results obtained it shows the properties of the low yield cross-ribbed bars. This indicates an error in raw materials selection and production is stopped instantly until corrections takes place.

Chemical analysis concluded the laboratory test. It endure that the chemical composition are in the right proportions. The elements usually tested for, are carbon, silicon manganese, phosphorus and sulphur.

D. Finishing control.

The finishing group uses cold shear gauge, scales and verniers for their measurements which involves 100% sampling. The temperature of finished product is carefully cooled. Then cutting of steel is done according to customers specification with minimum waste and relevant information on the quality/specification written on tag is attached the product. These include the heat number, manufacturers name, steel grade and size. For assurance of good quality control a tabular mill test report (technical data sheet) is given to the customers. This report by means of good record-keeping made available from the company to the engineers on site to enable them know the quality of materials available so that undue failure can be avoided.

3.5 Maintenance and Technical Services Department

The relevance of the maintenance function to the viability of steel rolling mills cannot be over emphasised, this is because the establishment of a production oriented plants, such as the Hadassa steel rolling company is usually characterized with phenomenal investment in heavy equipment and infracttural facilities. It has been estimated that such investment represent 85-90% of the capital out-lay /3/. This calls for the

need to have a maintenance function charged with the responsibility of attending day to day problems of keeping the mill equipment, machinery, building and services in good operating condition.

Its Function

That was why the maintenance/technical services department was established since the inception of the company as far back as 1981. Its major functions, among others, are to maintain and sustain the existence of the company /14/. To this effect, it focusses its attention on the machineries of the company, the transport system, renovation of existing structures and projects. The head of department is designated acting manager (or Acting Chief Engineer) having overall control of all the section under the department. He also take care of the staff administration of the department and the spare parts involved for the general repairs of the company's equipments.

Some years back, this department used to be a single unit, but now there are three different sections, under it; namely maintenance, Estate and Technical services. The maintenance section keeps the equipment and other functional facilities in good working order, so as to facilitate proper production. While the technical service unit provides the technical services required for production . It also take care of the safety of both staffs and equipment. The Estate department undertakes the maintenance generally of the infrastural facilities, example: houses, offices, mill, etc. The maintenance and technical

services are divided under the following sections: namely:-

a) Mechanical

b) Electrical

c) Technical services

d) Transport/vehicle workshop.

The four section are further divided into respective groups strictly in consideration of scope of the departmental functions. Each group is headed by a group leader of shift, because of 24 hour shift operation and one supervisory group leader. The supervisory group comprises of the foreman and an engineer. This (group) serves as a control and coordinating level or group between the group leaders and the Engineers.

The functions of the four sections mentioned could be summarized as follows:

Electrical maintenance section:

This section is in charge of numerous electrical system and utility outdoor maintenance. Among the activities carried out are:-

a) Periodical services/inspection of all D.C's and A.c's auxiliary motors.

b) Cleaning/fixing of all the lighting system of all mill.

c) Serving and inspection of all auxiliary equipment located at ware house.

d) General maintenance of all air conditioners and coolers located in the mill.

They also undertake the design and construction of a sequential circuit system which automatically stops the action of the

billet pusher in the case of an oversize billet trying to enter into the re-heating furnace. It also established a re-winding unit that will take care of 600 A.c and D.c motors.

Mechanical Section

This unit comprises of four groups these are:-

Mechanical maintenance

Mechanical repair

Roll-turning

Utility Operation

This section consist, among other things, a multi-skill group comprising of mechanist, welders andfilters/assemblers. This group handles from small work request to project which require adequate planning based on the high level of skill and management of the group leaders and the members of the group. It also undertakes routine standard maintenance practices. It has established inspection standards for the lubrication and hydraulic systems, main rolling ,mill equipment and auxiliaries based on the ranking group of production department.

Other work undertaken by this section includes improvement/modification constructions such as P102 emergency pipeline, compressed air supply extension to the control room and the roll-turning shop and water supply.

On the whole, the different engineering activities involved in the maintenance function can be grouped into two classifications These are:

a) Primary function

b) Secondary function.

Primary function require daily attention by the maintenance function as its main responsibility. The secondary functions are usually assigned to the maintenance department on accounts of expediency and capability. As a matter of fact there is no clear demonstration of the classification of scope of the maintenance function at HSRC. However from the checklist of the activities of the maintenance function the primary and secondary function can be classified as follows:

Primary Function

The activity includes repair to production equipment as quickly and economically as possible and to anticipate these repairs in advance through adaption of a high efficient concept of productive maintenance.

In addition the company undertake preventive maintenance in which every year, a month is set for general inspection and repairs; and every month, a day is set for maintenance aside from regular weekly checkings.

Secondary function

One of the major activities undertaken is store-keeping which includes, maintenance store-keeping, production storekeeping and general store keeping. This is because most of the tool accessories, spare parts and consumables relating to production

processes bear direct as well as indirect relationship with maintenance operations. This calls for need for store keeping which require separate inventory, accounting, issuing and purchasing procedures. Waste disposal is another activity. The waste that are disposed from time to time includes mill scales, misroll pieces, effluents, used oil, metal chips, and so on.

In addition, the maintenance department had devised what they call local fabrication unit in the company, with a repair shop where they modify, fabricate and make tolls/ equipment (spare part) that can be applied in the production line. This saves the company huge amount of money. An example, when the company had problem with gear in the burding shift, it was locally produced.

3.6 Management

The nucleus of the company's administration commenced operation in January, 1981 that was one month before its incorporation. Apart from the normal administrative work, which include among others, the formulation and implementation of a comprehensive plan for the smooth take off of the company, the management has an added responsibility of monitoring the progress of the work. That explain the reason why the small team of management staff was under the leadership of a project co-ordinator (who was later appointed the General manager).

Right from that time the function and organisational structure of administrative division has changed considerably. Finance department is not directly under administration and it

is headed by a Deputy General manager who performs dual role as the head of finance and administration department and each section is headed by a professional person. The Deputy General manager coordinate and ensure the roles are properly and efficiently played in order to achieve the desired objective.

The functions of finance and administration department could be summarised as follows:

Personal matters

The management is responsible for the entire staff matters. These include recruitment, discipline and promotion. For recruitment, the company advertise based on the request of the department and personnel section will take up the matter. Emphasis is given to the catchment area in the recruitment and the federal character requirement.

Staff welfare services

It also takes care of staff welfare services. So that the responsibility of articulation and application of the company's condition of service rest on the management. The company is the first among the five government owned steel companies to have what it calls " a befitting condition of services" which will make it possible for it to attract and maintain the best calibre of staffs. The major provisions in the conditions of service include:

1 Guidelines for recruitment and discipline

2 Pension scheme

3 Staff housing

4 Health care

5 Staff training

6 Overtime and shift allowances

7 Group personnel assurance.

Staff training

Another important area is staff training. For the fact that one of the main objective of establishing the steel industry is to serve as an avenue for transfer of technology, the management accorded priority consideration in the area of staff training. Infact, training arrangements were incorporated in the main contract agreement with foreign steel company. Most of the engineers and technicians together with the top members of the management staff have received their training either in overseas or in Nigeria. While many have enjoyed the benefits of local and overseas courses of refresher type. Company training centre has commenced full programme of training including arrangement of seminars.

Industrial relations

For the establishment and maintenance of harmonious relationship between the workers and management, industrial relation section was established. This led to the formation of the iron and steel senior staff association and the iron and

steel workers union (HSRC branch).

Staff Housing

Further, management is also responsible for making all necessary arrangement for the provision of reasonable accommodation to its staffs and those who con't get were given allowances as provided for in the condition of service. The company has a housing estate which is occupied by all categories of workers. There is rented quarters, also.

Health care and meal services

In addition, the management provides prompt medical attention to its staffs. There is clinic in full operation currently manned by a Doctor, superintendent, a dispenser and a dresser working on two shifts. Also, management gives free lunch to its staffs. There is canteen which was established right from the inception of the company.

Because of the hazardous nature of the job undertaken by most workers, management provides life insurance for staffs of the company under what it is called G.P.A. (Group Personnel Assurance) as provided by the government regulation under formerly workman compensation act which was later upgraded to GPA. There is also hazard allowance. Likewise transportation is provided to workers. If a staff is on duty tour, allowance is paid to him.

Security matters

Management is also responsible for the provision of security for the company. This section has a staff strength of fifty-two people. This vigilant security section works in close co-operation with both safety and fire services sections insuring the smooth and uninterrupted operation of the mill. The security division takes care of company, estate, clinic, and general managers house.

Public relations:

There is a public relations unit which tries to establish good relationship with the customers of the company, friends collegues, and well wishers. There is also a liaison office in Lagos which is part of the public relation unit. The liaison office deals with business in Lagos. It ensures that communication between steel rolling company and the ministry is smooth.

3.7 Commercial department:

This is the storehouse of the company as far as its effort towards the realization of the broad objective of profit maximisation is concerned. The department is headed by an assistant manager who oversees the various functions performed by the department and he reports directly to the general manager.

Its functions

The functions performed by the commercial department could be categorized under the following headings:-

1. Sales

The history of sales of the company's product could be traced back right from the year 1982; when, at the tail end of that year the company started trial sales of steel products. Almost all the products sold then were coils and most of the products were bought by the Nigerian Industrial Group Limited (NIGROUP) based in Kano. While the remaining products,were sold to another manufacturing company based in Kaduna. The quantity of products sold during that period was 2625 metric tons valued at #1,020,000.00 following the commissioning of the company on the 6th of December, 1982, full sales of the products commenced in February 1983. During that year, a total of 62,462 metric tons of steel bar and wire rods valued at #25,618,702.50 were sold.

Right from the initial stage, it was envisaged that the company should sell its products to all interested Nigerians and Nigerian companies but should particularly serve the needs of their immediate environment which would constitute their core market areas. As should be expected, due to the advantage of proximity, the commercial department has had more inquiries for business from steel dealers from our immediate environment than from other parts of the country infact the sales records of the company approximates this expectation.

However, it does not mean that there are no steel dealers from other part of the country. On the contrary, records of sales

shows that the steel products is bought throughout the country. For example records of 1983-84 shows nationwide acceptance of HSRC (Hadassa Steel Rolling Company) products as shown in Table 7.

TABLE 7: RECORD OF SALES OF HADASSA STEEL ROLLING COMPANY PRODUCTS FOR 1984.

TOWN	BAR (%)	COIL (%)
Aba	1.20	-
Benin	0.78	22.50
Enugu	0.30	-
Ilorin	1.40	1.55
Kaduna	3.00	11.70
Kano	18.60	29.20
Katsina	46.00	17.00
Lagos	4.10	13.20
Maiduguri	0.30	2.00
Onitsha	16.60	0.75
Sokoto	2.75	2.70
Zaria	5.00	-
Total	100.00	100.00

Source: HSRC (1995)

2. Procurement of raw materials

The commercial departments is charged with the responsibility of supplying company's production input. Such materials are:-

A. Billets: The department procured billets from the delta steel company ltd (DSC) Aladja. It should be noted, however, that Billets supplied by DSC are grossly inadequate as such the company import billets from oversees in order to augment the monthly requirements.

B. Fuel supply and other consumables: This department is also responsible for the procurement of consumables needed by the company for production and maintenance purposes. These include, among others, lubricants, oils, raw materials, for the local blending plants.

3. Marketing research

The importance of marketing research cannot be over emphasis as such, the commercial department has a marketing research team that undertakes the following activities.

A. Price monitoring: The team monitors prices of Hadassa steel rolling mill products and other related products with the aim of keeping abreast with vagaries of market forces especially, price fluctuations. In undertaking this function, they liaised with the price intelligence units of the ministries of trade and industries as well as federal and state offices of statistics for the purpose of verification of data collected from the market.

B. Market survey: These were carried out in order to ascertain viable market for HSRC products as well as the existence and location of competitors and sales/ marketing strategies. The survey also aimed at finding out the nature and the extent of market need for steel products.

C. Sales promotion and adverts

This is usually undertaken in conjunction with the public relation unit of the company, and it is aimed at informing the general public of Hadassa steel rolling company and, especially its products.

However, investigation carried out shows that some of the functions of the commercial department were not carried out. Example the marketing research, both the price monitoring and the market survey were not vigorously pursued because, according to one official he said that HSRC products are recognised as "good quality product" and that such function were done in the past that was why they earn the confidence of customers. So they are now "reaping the fruit of their past effort".

Though, contrary to the assertion made by the staff, in reality, reduction in the activities of this department may not be unconnected to the serious problem of raw, material- the billet, which led to very low production of steel products. Thus making some of these functions unnecessary and wasteful.

Although Hadassa steel rolling company does advertise its products from - time -to time though active participation in local trade fair especially the one organise annually by Kaduna chamber of commerce, Agriculture and industry. "Conventional"

advertisement in the news media both Newspapers and Radio is almost nil.

3.8 Problems faced by the Hadassa steel rolling company

In its effort to be counted as one of the steel producing nations, Nigeria made a huge investment in iron and steel industry to the extent that, today, it can boost of six steel companies. These are two integrated steel plants at Aladja and Ajaokuta, three inland steel rolling mills at Katsina, Jos and Oshogbo; as well as the national iron and ore company limited (NIOMC). This is a major investment aimed at not only making Nigeria self-sufficient in steel but also help in the promotion of technological, economic and social development of the country. It is also hoped that this will lead to the transformation of Nigeria into an industrial self-reliant nation.

Looking at the record of performance of iron and steel industry in Nigeria, it is really difficult to say confidently, that the aims and objectives of establishing them has been achieved. However, one thing that is very clear, is that these companies are faced with a lot of problems. For example in one of the comprehensive reports prepared by the central Bank of Nigeria (CBN), it said that Ajaokuta steel plant sustained an after tax loss of₦ 21m in 1987 only /8/. The report and the statement account indicates, also that sales turnover at the plant decline by 8.1% to₦ 92m while investment expenditure fell by 21.5% to₦ 452m. The light section mill (LSM) of the plant

with installed capacity of 400,000 tonnes operated for only four months during the year under review; and produced only 9,844 tonnes thereby utilising only 2.5% of its installed capacity. The wire Rod mill (WRM) of the plant operated for only six months of the year and produced 13,906 tonnes against its installed capacity of 795,000 tonnes produced just 400 tonnes during its last run /8/.

The report also indicated that the performance of Delta steel company was poor. For example , the capacity utilization declined from 16% in 1986 to 14% in 1987. While that of the year (1994) was even, worse. The report blamed the low production level of DSC on the sharp decline by 78.4% of federal government grants for the importation of raw materials in 1986. Federal government grants to DSC progressively declined from₦ 106.1 million in 1983 to₦ 5.7 million and₦ 3.4m in 1984 and 1985 respectively and declined further to₦ 2.3million in 1986 and only ₦ 0.5 million in 1987. The company's poor working capital position was accentuated by its high gearing ratio (Loans to equality) of 5.1 which restricted its access to the financial markets. Other problems encountered by DSC included the non-dredging of the Warri River which made transportation difficult and expensive, the unviable price of billets and rising operational costs resulting from the depreciation of the value of the Naira.

On the other three inland rolling mills, they all experienced problems of inadequate fundings, inadequate local supply of billets from the steel plants and shortage of foreign

exchange to procure billets and spare parts. The report indicated that in spite of the local demand for steel products of about 3.5 million metric tonnes a year, the mills inevitable low production, made it difficult for them to satisfy consumer demands, and generate profit.

ii Hadassa steel rolling company

Hadassa steel rolling company just like any of the six steel companies in Nigeria, is also faced with many problems which has ultimately affect the company. This is very clear from close look at the record of performance of the company right from its commissioning in 1983 to date. For example, the company was planned to have production capacity of 210,000 metric tonnes per year based on a specified production mix of reinforcement bars and wire rods. The capacity was expected to expand to 420,000 metric tonnes per annum at the second stage and 720,000 metric tonnes per year at the third stage /16/.

However, records shows that the highest production ever achieved was in 1985 where 75,000 metric tonnes was produced this represent only 35.7% (thirty-five point seven percent) of the installed capacity at the first phase this is shown in table 8 below. While in 1994 less than 10,000 tonnes was produced.

TABLE 8:HADASSA PRODUCTION RECORD (1982 - 1994) IN TONS

TABLE 8: Hadassa Production Record (1982 - 1994) in tons

PRODT SIZE		1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	TOTAL
5.5	PC	0	0	259.8	1538.	3758.7	4064.5	590.77	5291.8	5046.0	5923.4	4107.2	983.56	6181.	37741.891
6	PC	2092.12	1220	6368.	8791.	4787	659.74	7333.21	16521	206.94	0	525.9	0	0	044617.53
6	DC	0	0	0	0	2271	977.45	0	0	10.23	0	0	0	0	3258.68
8	PC	37.68	1003.	0	2719.	881.45	123.59	0	873.75	31.95	391.24	260.86		0	6323.243
8	DC	0	414.3	0	4705.	8201.4	3240.5	917.61	1233.4	789.89	254	173.97	0	920.5	20850.98
10	PC	0	1215.	596.7	1113.	0	0	289.590	0	199.61	342.37	342.37	0	0	3757.15
10	DC	0	502.6	868.2	1205.	0	0	0	0	0	0	0	0		2576.27
12	PC	0	0	0	0	119	0	0	0	201	0	0	96.886		416.886
COIL TOT		2129.8	1533	8093.	20070	20019	9065.7	9131.1	9051	6485.69	5911.04	5067.9	1080.4	7101.	119542.634
10	PB	0	0	0	1011.	891.76	2042.7	8602.2	5130.1	2407.7	2844.8	4139.7	2721.3	12394	42186.6737
10	DB	0	0	0	2757.	10039	6815.6	9665.6	5892	6460	4001.65			5722.	54019.384
12	PB	722.11	1182	3657	12639	6812.6	884.13	146.6	0	0	0	59.32	0	0	041746.9
12	DB	530.47	1089	7679	12691	10760	4419.7	2035.25	1265.3	653.94	1747.49	742.94	1134.4	6182.	60740.8694
14	PB	744.77	7159.	537.1	5310.	6281.9	2614	0	0	0	0		62.05	0	22709.62
14	DB	206.11	3719.	1082.	3291.	2210.5	1832.4	0	0	0	0		1394.7	1373.	15110.952.
16	DB	1446.86	1516.	0	395.2	406.55		0	0	190.68	0		0	0	4045.95
16	DB	27.3	2728.	0	5445.	2895.8	889.83	1041.49	1781.19	200.96	455.67	998.76		1621.	18086.36
18	PB	20.06	1197.	0	233.4	311	73.59	0	0	0	0		0	0	1835.86
18	DB	2167.34	188.6	3781	0	1180.1		0	0	0	0		0		7317.06
20	PB	378.32	1003	0	0	63.94	260.18	0	0	0	15.58		0		1721.02
20	PB	0	1073.	369.1	2592.	1752.2	1079.1	1084.25	613.99	446.78	258.13	166.49		500.7	9936.614
22	PB	248.06	0	0	0	0	0	0	0	0	0	0	0		248.06
22	PB	112.87	0	0	0	0	0	0	0	0	0		0		12.87
25	PB	3657.7	0	351.6	4357.	0	771.31	1 1019.3	24.014	161.51			0	100.3	10963.8
25	DB														0
32	PB						40.35	78.44	487.66						606.45
32	PB	18.7													18.7
BAR TOTAL		10280.7	4130	22459	50725	43695	21722.	23673.2	15414	10522.5	9626.15	8622.1	5463	27895	27895.2789
GRAND TOTAL		12410.5	5664	30552	70795	63714	30788.	32804.4	24465	17008.2	16537.1	13690.	6543.4	34997	16537.654

DB - Deformed Bar
DC - Deformed Coil
PB - Plain Bar
PC - Plain Coil
COIL TOT- Coil Total
SOURCE: HSRC (1995)

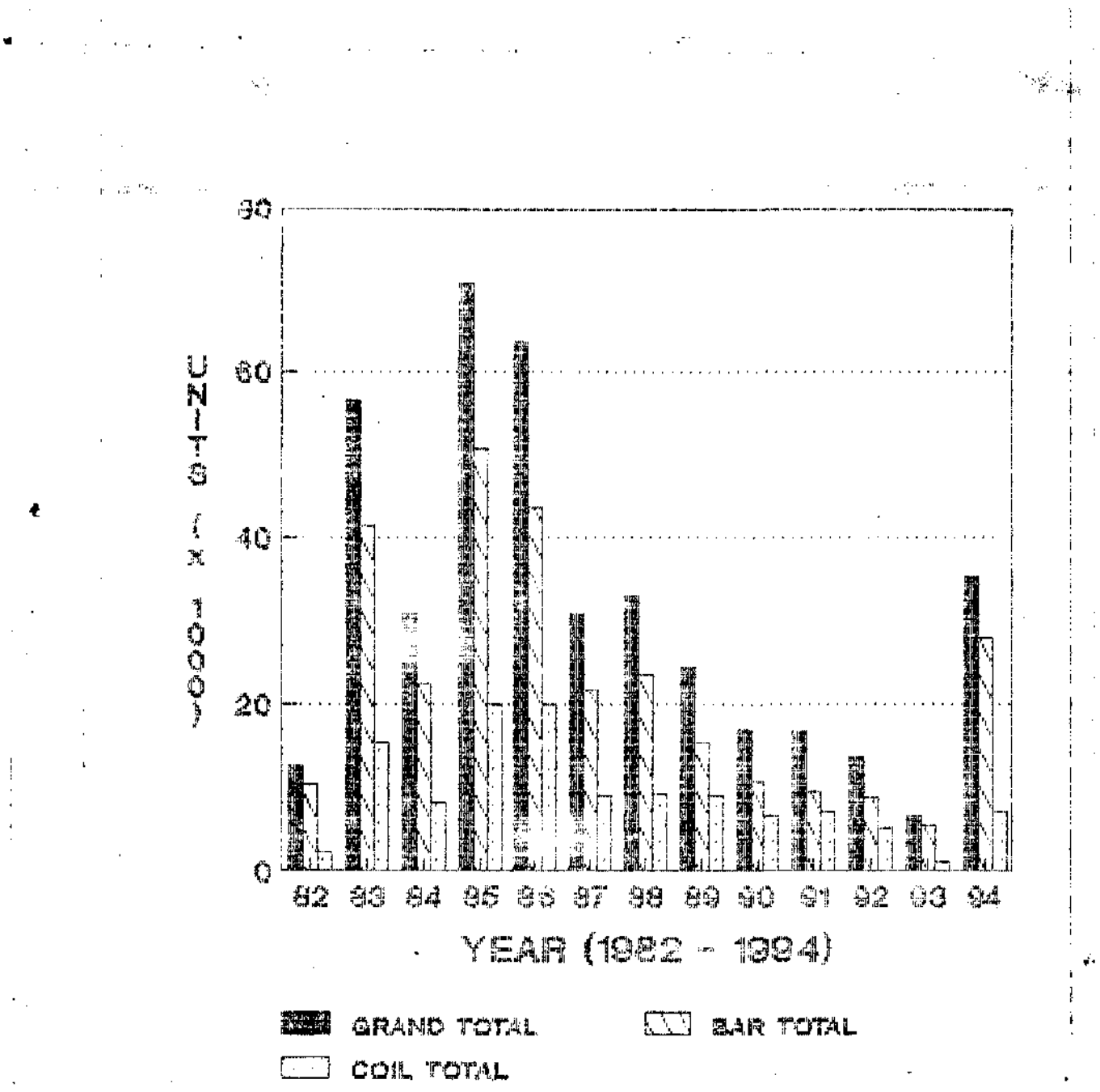


Fig. 13: Production records of HSRC (1982-1993)Source HSRC.

In one of its editorial comments, a quarterly newsletter of the company sum up the above fact as follows:

> "When a factory is producing but is unable to produce the required quality commensurate with its installed production capacity, we say the factory is producing below installed capacity. Furthermore, when the factory is at one percent of its capacity, it cannot be said that the factory was shut down but there exist a serious problem of a very low capacity utilization".
>
> "Truly, this has been the situation with many manufacturing industries in Nigeria including Hadassa steel rolling company....." /17/.

Investigation reveals that erratic and poor raw material (Billet) supply could be sighted as one of the compounded problems /17/. Infact over ninety percent (90%) of those people interviewed regard this as the major problem. All the general managers both past and present, have, at some occasions lamented on this problem. This is because all the three inland rolling companies depend on Delta steel company (DSC) for the supply of their basic raw material (Billet), and so DSC is unable to cope with the demand since it is faced with the problem of insufficient raw material because the basic ingredients (iron ore) is imported. There is no doubt that, lack of raw material seriously affect the production process and this in-turn affect the overall progress of the company.

Because raw materials is the life wire of the company. There are occasions when the company had to go on recess due to lack of raw materials. It was not long ago to be precise-in the months of may and June 1995 the company was closed down because there was no billets. Even after the delivery of the billets, the company had to operate on only one shift instead of the normal 3 three shifts. This means that for every three (3) workers, two were either idle or are working far below their output . This is a very big loss especially considering the statement made by the first Deputy general manager Administration /25/ in which he said

> " effective use of time is one of the essential parameters considered by the management of all production companies..... a lot of production lasting for a single costs the company huge loss (of about₦ 70,000)."

Considering the exchange rate of Naira to other currencies and the time he made this statement, the lost is now far over and above that amount. Thus, it could be seen how much it cost if a whole month or two is wasted or if say, 8 'hours is spent instead of the normal 24 hours (3 shifts).

This is the reason why the company restore to importation of Billet from overseas. Even then, there are alot of problems associated with such an exercise. First, it is not simply the issue of buying an article of good in the supermarket where you can just give naira and collect it. It involves foreign

exchange which the country is in dire need; more than ever before. Secondly, the transaction involves two parties that live at two separate ends of the world so the transaction largely depends on correspondence, with the banks as intermediaries as well as guarantors. These banks tent to be meticulous in their dealings with the customers/parties involved. Each document submitted is well scrutinize besides that, there is the problem of selecting the companies and identifying which of the companies who applied for supplying and clearing of the billet is qualified to do it. After selecting such company, there is onerous task of negotiating the terms of agreements, with each party trying to see that the contracts agreement is to its favour. Having reached an agreement, there is another very big hurdle. That is, the transportation of the billet from overseas to Nigeria. This is almost, always met with some problem. Sometimes the problem starts right from overseas-where the billet was ordered. For example,in the year 1994, billet was ordered since september (1994) but it did not reach/arrive Hadassa company until september 1995, exactly one year after. This was because after the order was placed for the purchase of the billet, there was earthquake which, seriously affect the clearance of the billet to Nigeria.

After the arrival of the billets another problem that face the company is the issue of congestion at the ports, with vessels carrying other goods. In addition the problem became more compounded because of lack of spare parts for trucks,

which serves as the means of transporting the billet from the port to the premises of the company.

Another problem that face the company is the issue of identification of the billet, when it is brought from the port to the premises of the company. Because the billet is procured in the world market; from different countries and, usually, the billet is accompanied by manufacturers certificate, with weight bill, delivery note and colour coding. This gives information about the quality of the billet. Now, in some, instances the billet is accompanied by only the colour coding which gives information on the chemical composition of the billet using colours. Unfortunately there is no unified standard/system for such (colour) coding,so that it ultimately affect the quality of steel produced because the carbon content determines the type of steel produced and the diameter of such steel. Although the manager maintenance and technical services said that "HSRC had expanded its scope of material testing activities by extending analysis on incoming raw materials. Billet inspected or ultrasonically tested and found to have internal defect or surface imperfection were outrightly rejected and considered unfit for rolling". However, investigation reveals that "the greatest obstacles the quality control laboratory faced were, unsteady and unregular supply to chemicals and reagents from local suppliers. Spare parts for some sophisticated equipment and apparatus". These and other problems led to the mark reduction in the number of test carried out. Testing of Billet is not taking place now. Even

though according to the annual performance review of 1984, over 30 number billets were (tested) and found to have such defects /1/.

From the foregoing, could it be concluded that lack of raw materials is the one and only major problem facing the company? while it could be admitted that it is one of the major problem, but it is by no means the only one. The issue of raw materia has always been what can be regarded as " re-occurring decimal" in most of the manufacturing industries in Nigeria. So the expert insist that local sourcing will do the magic-of solving the problems of most manufacturing industries in Nigeria. However,critical analysis of the problem will show a much more fundamental problem. For , it should be noted that there are certain parameters which influence the location of a steel production plants. This includes among others, the following:- /12/.

1. Availability of enough space in terms of land.
2. Topographic and geological features like bearing capacity. Environmental eventualities such as floods and earthquakes are considered when necessary.
3. Enough amount of water. In this angle, both source and transportation of the water are taken into consideration.
4. Availability of reliable, steady and adequate electric power supply.
5. Labour, transportation, communication capabilities and a host of others.

Above all, there is also the political consideration to disperse industries in this country (so as) to satisfy market demand and meet the constitutional requirement which will make our nation more politically and economically stable. /11/

There is no doubt, that the location of this rolling company has satisfy most-if not all-of these requirements. However the present location of the three inland rolling mills (Hadassa HSRC inclusive) tends to give the impression that much consideration was not given to the viability of such plants right from the planning stage. Because the operation of steel making plants involve the movement of huge amount of raw material and finished products to and from the plants over long distances. For instance, it was estimated that in the first phase of the inland rolling mills, 630,000 tonnes of billets will be transported from Delta steel company to rolling mills and about 1 million tons will leave the rolling mills at the town of location, that is, Katsina, Jos, Oshogbo, Delta steel company and Aladja to the Nigerian markets. So the creation of efficient transportation system should have been foremost in locating the sources of raw materials. Because that will solve many problems especially when we consider the fact that the rolling mills are supplied with billet from Delta company which is thousands of kilometres away from each of inland steel companies including Hadassa steel rolling company which is about 400,000 kilometers from DSC. In addition, the transportation of billets from Delta steel company are undertaken using trucks (i.e by roads) despite appeals made by

experts and the number of promises made by the past governments that they will link HSRC with Delta (DSC) with railway system even though the present operational condition of the national railway system is a bit far from being favourable for transporting billets between DSC and the inland rolling mills. Because the existing railway system is an obsolete single track with passing points at about twenty (20) km intervals. In addition, the present rail system is made in such a way that there is no provision for a separate tracks for trains that will be meant for special purpose which, at the sametime, would not hinder the smooth movement or operation of other trains. The modernisation of the railsystem will be anything but easy taking into consideration the present economic situation.

Equally serious, is the issue of spare parts. This is because as mentioned in the previous section, the establishment of steel company is characterized by phenomenal investment in heavy equipment and infrastructural facilities which represent about 85-90% capital outlay /3/ such as equipments needs repairs and replacement, at times some, even become obsolete, requiring complete change to cope with the increasing technological advancement, this brings the need for spare parts to keep the company going; most of these equipment parts are imported. It requires foreign exchange which is difficult now and needs time. Another thing that makes the problem worse is over-dependence on oversees partners or " mother factory" for the supply of such things; these are kind of offsprings of a perpetual marriage between HSRC and its overseas partners.

Although to be fair, to the HSRC, the workers have the "adventurist spirit" to produce some spare parts. But spare parts is still a problem to the company.

In addition, constant change of government, also affects the company in no small measure. Right from the establishment of this company in 1983 to date, Nigeria had five regimes. This unfortunately, leads to change in policies, constant change of ministers and board members of the company. Another relevant point is the change in the management approach of the chief executives of this company (the G.M). Because there was a period in the history of this company HSRC, when it was "the most consistent, reliable and highest producers of rolled steel out of all the inland rolling mills" /18/ it was regarded as the best managed company out of the steel companies. However after change of hands at the HSRC at the number one seat, the situation is no longer the same or normal. The company suddenly change from "riches to rags" with its accounts in the red (at a point in time). The company was unable to pay even salaries and allowances of its workers. The situation was further aggravated by government, through inadequate funding. According to Kera /20/ most, if not all, of the ,steel companies had no capital until 1988 when government gave them #70 millions. HSRC and one of the inland steel rolling company, have not been provided with working capital since their inception.

However, at the initial take off of the company, it (HSRC) enjoyed all the necessary support from the then civilian

administration (Shagari's regime) including adequate funding. One big mistake on the part of government is its failure to instill the necessary discipline to the company by possibly, setting a target date for the company after which the company is expected to be self-reliant and also making a " follow-up" to ensure that the money given to the company is used judiciously. There was also the allegation made against the government interference on the pricing policy of the company.

Although with the problem of dumping of foreign-made steel in the country there is high doubt that non-interference of government will make much difference. Actually, the dumping of steel products made from outside the country do a lot of harm because of the lower cost of producing such steel by their manufacturers, they are able to export them at relatively lower price than the steel made in Nigeria. This, ultimately affects the prices of steel produced at Hadassa Steel Company.

Worse still, there is no any serious effort made by the government to stop the illegal importation of the steel products from outside. Infact, one could say that governments is indirectly supporting the importation of steel products. This is because,in the year (1994),government approved the importation of steel reinforcement from overseas, for the implementation of the housing policy introduced by the Federal government at the beginning of 1995; despite the fact that there are steel companies in the country; instead of assisting some or all steel firms in Nigeria, by providing adequate funds for the production of the steel.

Another very serious problem faced by this company is corruption and mismanagement of the meagre resources of the company. Just like any public enterprise in which it is regarded as nobody's property and so any person could make use of it for his personal benefit - given the chance; HSRC has an unenviable record of corruption and mismanagement. This include unnecessary and excessive spending, going to overseas for "medical treatment" misappropriation of funds etc. In addition, the commercialization of its services as a result of the Low capacity utilization arising from lack of raw materials(billet), though a good idea and a way out of idleness by the workers; was nonetheless grossly abused. There is no well articulated guidelines with fees of the services offered by the company. Investigation reveals that such services was offered to some privileged Nigerian.

On the other hand, campaign by the world bank officials who visited this country and urged the government to stop the steel project, because, according to them, it was unnecessary and inviable, has further added problem to the steel rolling company. Perhaps this, coupled with the above mentioned problem of mismanagement leading to huge losses, encourage the government to develop a cold feet and deliberately starve this company (HSRC) and other steel companies, of fund-and other necessary support.

One very important issue which is worth mentioning is politics. By this, it is meant the interference of political consideration in many important decisions or policies that

affects the company and, unfortunately more often than not, such political consideration are given undue and unnecessary precedence over economic consideration. The heterogenous nature of the country in addition to the geo-political dichotomy, on many occasions, hinder the implementation of viable projects that could help the country move forward. For example, some years back, that was 1984, Hadassa steel rolling company undertook feasibility studies on the expansion of the company, so that it can produce steel. After undertaken such studies, it was found that it was going to be viable so it was recommended that a plan be drawn-up for the expansion since it will help in solving many or most of the problem facing the company and further assist in the production of more steel with very little or no problem. It was estimated that it will cost not more than₦ 200m (two hundred million naira). As at that time (in 1984) the exchange rate was₦ 1.00 (one naira) to zero point nine yen (0.9 yen), while as at now it is three hundred and sixty naira to one yen !!! so that according to one steel expert it will now cost the government more than one billion naira. which, taking into consideration, the present economic realities, it is almost impossible, so, it can be seen that back in 1984 there was money to implement except that government was unwilling to implement it due to political consideration.

We have reached a time in the history of steel companies in Nigeria, when government is, by implication, admitting that it can no longer fund and manage these companies-at least

judging from its attitude in recent years. If the news, aired in BBC (British Broadcasting Corporation) is anything to go by, government is seriously considering calling the Russians to take over the management of the biggest steel company in Nigeria, that is Ajaokuta steel company. That it has, so far, spent well over five billion Dollars on it but the company is faced with alot of problems and it is the same story with Delta steel company.

Unfortunately, the problems of Hadassa steel rolling company can not be divorced from the ones faced by other steel companies because it largely depend on Delta steel company for the supply of billets (raw materials). Added to the fact that the foreign partners or rather contractors who executed the construction of these companies are from different countries. That is why there are some form of "mix-up' in the standard used by these companies. For example DSC was built by Germans and Katsina steel company by the Japanese while Ajaokuta by Russians. So that explains why HSRC, for instance, use manuals, machines and standard from overseas for products but in giving information about their products (Data sheets), German standard was used for that purpose because the billets are produced from Delta, which is build by the Germans.

The last issue, which is, by no means the least, is the issue of staff welfare-including their salary. It is true that almost all the organizational set-up of HSRC is in overseas fashion. The workers, especially most senior ones have received some form of training in overseas and in the process, have

acquired good altitude towards work similar to that of foreign partners. But one thing missing is the condition of service (salary and allowances) it is far from that of other companies abroad. The management has certainly made concerted effort towards that end which brought the formation of a special scale for its workers. Infact it was the same salary structure that was used as a base by other steel companies to prepare their own /23/. Added with incentives introduced by the company to motivate its employees, most of these incentives are non-financial in nature. But the fact remains that workers salary is not fit for their status-as steel workers. Talkless of the incentives, in Japan for instance, there is a government regulation which stipulates that overtime rates should not be less than 25% of basic salary/28/. However overtime rates for steel workers in Japan is 30% which means more than 5% above government rate is paid to such workers. There is also the Hazard allowance which is determined by the content of work and assessed using some criterion such as the physical burden and hazard of danger /28/.

Another important issue worth noting is the altitude of people at the helm of affairs of public enterprises with regards to planning and implementation of such plan. Unlike the private sector where a painstaking plan is made with a clearly defined objective, and every stage of the production process is costed very well so that the entire arrangement is "intend, planned and administered to succeed" /6/ while in most government parastatals events tend to show indifference to

performance let alone efficiency or profitability. All this affect government parastatals and companies of which Hadassa steel rolling company is one of them.

CHAPTER FOUR

EXPERIMENTATION AND TEST RESULTS

4.1 Preamble

Various sizes of steel reinforcement produced by the Hadassa Steel Rolling Company (HSRC), were collected directly from the company, and brought to the Heavy Structural Engineering Laboratory, Department of Civil Engineering, Ahmadu Bello University, Zaria. These steel bars were prepared to test pieces in accordance to the BS 4449 (1970), BS 18 part 2 (1971) and BS 1639 (1964).

The test pieces were, then, subjected to tensile test Elongation test and Bend test. Deviation on cross-sectional area, deviation on nominal mass per metre-run and nominal density were determined in accordance with BS 4449:1970 clause 4,9,11 and 22.

4.2 Samples used for Test

All the samples used for the experiment were produced at Hadassa steel rolling company (HSRC). Two types of steel reinforcement were used for the purpose of this research work. These are :

(1) High yield hot rolled deformed bars of diameters 25mm,20mm,16mm,12mm and 10mm.

(2) Mild steel, hot rolled plain bars 10 millimeters diameter.

Each of the test bar is labelled with an alphabet. This is just for easy identification and bears no relation with the quality of the steel bars nor with the method of production.

Diameters 25 millimeters is labelled A,while 20 labelled B and so on, as shown in Table 9.

TABLE 9: SAMPLE SIZE WITH IDENTIFICATION MARK

SAMPLE No	DIAMETER [mm]	IDENTIFICATION MARK
1	25	A
2	20	B
3	16	C
4	12	D
5	10	E
6	10 (mild)	F

Furthermore, in order to identify each diameter sample, within a particular diameter, numbers were used. For instance sample 1 with diameter 25 is identified as A-1, A-2, A-3, to A-10 and sample 2 with diameter 20 is identifies as B-1, B-2, B-3... to B-10. The same thing applies to the remaining sample 3 to 6.

While for Bend test, the same alphabet were used but number is increased serially as shown in Table 10 below. TO identify each sample specimen, it is as shown in Table 10.

TABLE 10: SAMPLE SIZE WITH IDENTIFICATION MARK FOR BEND TEST

SAMPLE No.	DIAMETER [mm]	IDENTIFICATION MARK
7	25	A
8	20	B
9	16	C
10	12	D
11	10	E
12	10	F

Four pieces were used for each diameter. Each of these samples were identify as shown in Table 11.

TABLE 11: BEND TEST - SAMPLE WITH IDENTITY MARK

SERIAL No	SAMPLE No.	DIAMETER [mm]	IDENTIFICATION MARK
1	7	25	A-11
2			A-12
3			A-13
4			A-14
5	8	20	B-11
6			B-12
7			B-13
8			B-14
9	9	16	C-11
10			C-12
11			C-13
12			C-14
13	10	12	D-11
14			D-12
15			D-13
16			D-14
17	11	10	E-11
18			E-12
19			E-13
20			E-14
21	12	10	F-11
22			F-12
23			F-13
24			F-14

The choice of various diameter of steel used for the test was based on the available product and the usual common frequent bars produced as discussed in chapter two. These diameters are also the usual bars used in construction industry.

4.3 Tensile Testing

Prior to the test, specimen bars were cut to the required length (500mm) using mechanical saving machine, this was followed by marking of the gauge length and then, they were weighed. Later, they were fixed in the testing machine. The

method of gripping of the test piece to the machine used and all the testing procedures were carried out in accordance to BS 18 part 2: 1971. The test was performed using MFL UT system tensile testing machine, type ECS 11 No 551. This is a computerized machine with a plotter which is non functional.

All the factors affecting the determination of tensile properties of steel as contained is the BS 18 part 2: 1971 were carefully noted. accordingly, the test was undertaken at laboratory room temperature.

About 10 samples for each diameter were used for tensile strength as specified by BS 18:part 2 and BS 4449. The results are shown in Tables 12 to 17.



PLATE 1 : Sawing machine; used for cutting bars



PLATE 2 : Tensile testing machine (MFL UT System model)

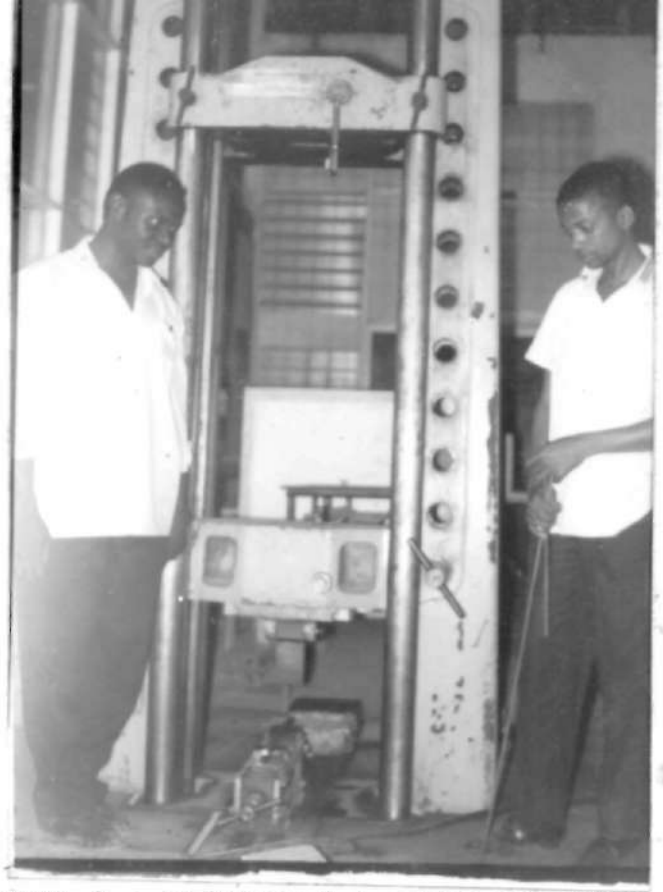


PLATE 3 : Universal testing machine.



PLATE 4 : Bars after Bend test.

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PLATE 5 : Bars after tensile test.

4.3.1 Tensile Test Results

TABLE 12: TENSILE TEST RESULTS FOR DIAMETER 25mm

SERIAL No	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	A-1	-	662
2	A-2	-	651
3	A-3	-	656
4	A-4	-	656
5	A-5	-	658
6	A-6	-	656
7	A-7	-	657
8	A-8	-	656
9	A-9	-	662
10	A-10	-	653

It could be seen that there is no yield stress. This is due to the absence of yield point shown in all the ten specimen bars tested. While the average ultimate strength is 657N/mm^2.

TABLE 13: TENSILE TEST RESULTS FOR DIAMETER 20mm

SERIAL No.	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	B-1	274	382
2	B-2	274	398
3	B-3	271	398
4	B-4	271	392
5	B-5	271	392
6	B-6	271	395
7	B-7	274	382
8	B-8	274	382
9	B-9	274	382
10	B-10	271	382

The above results shows an average of 273N/mm^2 yield and 389N/mm^2 yield strength and ultimate strength respectively.

TABLE 14: TENSILE TEST RESULTS FOR DIAMETER 16mm

SERIAL No.	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	C-1	368	627
2	C-2	358	557
3	C-3	363	557
4	C-4	363	552
5	C-5	363	582
6	C-6	368	627
7	C-7	358	552
8	C-8	363	587
9	C-9	368	587
10	C-10	378	612

The results show that the average yield strength of 16mm diameter bars is 365N/mm^2 and the ultimate strength is 584N/mm^2.

TABLE 15: TENSILE TEST RESULTS FOR DIAMETER 12mm

SERIAL No.	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	D-1	398	611
2	D-2	398	602
3	D-3	398	611
4	D-4	398	602
5	D-5	398	602
6	D-6	398	602
7	D-7	398	602
8	D-8	398	602
9	D-9	398	602
10	D-10	398	610

The average yield strength for 12mm diameter bar is 398N/mm^2 while the ultimate strength is 605N/mm^2.

TABLE 16: TENSILE TEST RESULTS FOR DIAMETER 10mm

SERIAL No.	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	E-1	459	573
2	E-2	484	573
3	E-3	459	573
4	E-4	497	662
5	E-5	459	573
6	E-6	471	662
7	E-7	459	573
8	E-8	459	573
9	E-9	497	500
10	E-10	459	573

Compared with the previous results, the average yield strength is 470N/mm^2 while ultimate strength is 583 N/mm^2.

TABLE 17: TENSILE TEST RESULTS FOR DIAMETER 10mm (MILD STEEL)

SERIAL No.	IDENTIFICATION MARK	YIELD STRENGTH [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]
1	2	3	4
1	F-1	357	459
2	F-2	344	497
3	F-3	344	484
4	F-4	357	484
5	F-5	344	446
6	F-6	344	446
7	F-7	306	459
8	F-8	357	484
9	F-9	344	471
10	F-10	306	484

The average yield strength is 340N/mm^2 while the ultimate yield strength is 471N/mm^2.

4.4 Bend Test

The same sizes of reinforcing steel were subjected to bend test in accordance with standard. That is, BS 1639 (1964) and BS 4449 (1970) clause 19.1. The results are as shown in Tables 18 to 20

TABLE 18: BEND TEST RESULTS FOR 25mm AND 20mm DIAMETER BARS

SERIAL No.	IDENTIFICATION MARK	SAMPLE	SIZE OF FORMER DIAMETER [mm]	TEST OBSERVATIONS
1	2	3	4	5
1	A-11	7	78	There are some cracks on the steel specimen (bars).
2	A-12		78	
3	A-13		78	
4	A-14		78	
5	B-11	8	63	No cracks or failure of the said diameter of former during bending.
6	B-12		63	
7	B-13		63	
8	B-14		63	

Thus, it could be seen that sample 7 has failed the test while sample 8 (20mm diameter) has passed the test.

TABLE 19: BEND TEST RESULTS FOR 16mm AND 12mm DIAMETER BARS

SERIAL No.	IDENTIFICATION MARK	SAMPLE	SIZE OF FORMER DIAMETER [mm]	TEST OBSERVATIONS
1	2	3	4	5
9	C-11	9	53	No cracks or failure of the bar at the diameter of former during bending.
10	C-12		53	
11	C-13		53	
12	C-14		53	
13	D-11	10	39	-do-
14	D-12		39	
15	D-13		39	
16	D-14		39	

Both samples 9 and 10 passed the bend test as there are no cracks on the bars during bending.

TABLE 20: BEND TEST RESULTS FOR TWO 10mm DIAMETER BARS

S/N	IDENTIFICATION MARK	SAMPLE	SIZE OF FORMER DIAMETER [mm]	TEST OBSERVATION
1	2	3	4	5
17	E-11	11	33	No cracks or failure of the bar at the said diameter of former during bending.
18	E-12		33	
19	E-13		33	
20	E-14		33	
				-do-
21	F-11	12	23	
22	F-12		23	
23	F-13		23	
24	F-14		23	

Since no cracks appeared on both bars, they could be deemed to have passed the test.

4.5 Elongation Test

This test was undertaken in accordance to the BS 18 (1970) Method for tensile testing of metals. The results are shown below, in Tables 21 to 26.

TABLE 21: ELONGATION TEST RESULTS FOR 25mm BARS

SERIAL No	IDENTIFICATION MARK	GAUGE LENGTH [mm]		ELONGATION [%]	Kinds and position of failure
1	2	3	4	5	6
1	A-2	125	145	16	Failed and
2	A-2	125	145	16	necked
3	A-3	125	150	20	within the
4	A-4	125	143	14	gauge
5	A-5	125	145	16	"
6	A-6	125	145	16	"
7	A-7	125	145	17	"
8	A-8	125	145	16	"
9	A-9	125	145	16	"
10	A-10	125	145	16	"

The average percentage elongation is 16 percent only two percent above the minimum allowed by BS 4449 with sample A-4 having just the minimum allowed.

22: ELONGATION TEST RESULTS FOR 20mm BARS

Serial No	Identification mark	Gauge length [mm]		Elongation [%]	kinds and position of failures
		initial gauge	final gauge		
1	2	3	4	5	6
11	B-1	100	128	28	Failed and necked within the gauge
12	B-2	100	128	28	
13	B-3	100	128	28	"
14	B-4	100	128	28	"
15	B-5	100	128	28	"
16	B-6	100	128	28	"
17	B-7	100	128	28	
18	B-8	100	128	28	
19	B-9	100	128	28	
20	B-10	100	128	28	

The average percentage elongation for the above sample is 28 percent. Twice as much as the minimum allowed.

TABLE 23: ELONGATION TEST RESULTS FOR 16mm BAR

Serial No	Identification mark	Gauge initial gauge	length final gauge [mm]	Elongation [%]	Kinds and position of failures
1	2	3	4	5	6
21	C-1	80	128	60	failure and necked within the gauge
22	C-2	80	128	60	
23	C-3	80	128	60	"
24	C-4	80	128	60	"
25	C-5	80	128	60	"
26	C-6	80	128	60	"
27	C-7	80	128	60	
28	C-8	80	127	59	
29	C-9	80	128	60	
30	C-10	80	126	58	

The average percentage elongation is 60 percent; well above the minimum allowed by B 4449. Failed and necked within the gauge length. All pass the test.

TABLE 24: ELONGATION TEST RESULTS FOR 12mm BAR

Serial No	Identification mark	Gauge initial length initial length [mm] final gauge		Elongation [%]	Kinds and position of failure
1	2	3	4	5	6
31	D-1	60	105	75	failed
32	D-2	60	105	75	and
33	D-3	60	105	75	necked
34	D-4	60	105	75	within
35	D-5	60	105	75	the gauge
36	D-6	60	105	75	"
37	D-7	60	105	75	"
38	D-8	60	105	75	"
39	D-9	60	105	75	"
40	D-10	60	105	75	

The average percentage elongation is 75 percent; passed the elongation test but it is high.

TABLE 25: ELONGATION TEST RESULTS FOR 10mm BAR

Serial No	Identification mark	Gauge length [mm]		Elongation [%]	Kinds and position of failure
		initial gauge	final gauge		
1	2	3	4	5	6
41	E-1	50	67	34	failed and
42	E-2	50	67	34	necked
43	E-3	50	66	32	within the
44	E-4	50	66	32	gauge
45	E-5	50	66	32	"
46	E-6	50	66	34	"
47	E-7	50	66	32	"
48	E-8	50	66	32	"
49	E-9	50	65	30	"
50	E10	50	65	30	"
					"

The average percentage elongation is 30 percentage well above the minimum allowed BS 4449.

TABLE 26: ELONGATION TEST RESULTS FOR 10mm BAR (MILD STEEL)

Serial No	Identification mark	Gauge length [mm]		Elongation [%]	Kinds and position of failure
		initial gauge	*final gauge*		
1	2	3	4	5	6
51	F-1	50	70	40	Failed and
52	F-2	50	69	38	necked
53	F-3	50	70	40	within the
54	F-4	50	70	40	gauge
55	F-5	50	70	40	"
56	F-6	50	68	38	"
57	F-7	50	70	40	"
58	F-8	50	70	40	"
59	F-9	50	70	40	"
60	F10	50	70	40	

The average percentage elongation is 40 percent. It has satisfied the minimum requirement though too high, more than twice as much as the amount allowed by BS 4449.

CHAPTER FIVE

ANALYSIS AND DISCUSSION OF RESULTS

5.1 Preamble

As it was mentioned earlier, the strength parameters considered in this research which include tensile strength, yield strength and characteristic strength, were determined in accordance to BS 18- method for tensile testing of metals and BS 4449- specification for hot rolled steel bars for the reinforcement of concrete and BS 8110.

The results obtained from the laboratory test and which was presented in chapter 4 are discussed and analysed under the following headings. The method of analysis as presented by Prof.Draffin /26/ would be used .

5.2 Characteristic strength.

TABLE 27: CHARACTERISTIC STRENGTH

SERIAL No.	SAMPLE LABEL	DIAMETER [mm]	CHARACTERISTIC STRENGTH [N/mm^2]	BS 4449 MINIMUM VALUE REQUIRED [N/mm^2]
1	A	25	-*	410
2	B	20	270	410
3	C	16	355	410
4	D	12	398	410
5	E	10	443.6	410
6	F	10	309.4	250.

* **No Characteristic Strength.**

From Table 27 above it can be observed that, the first specimen bar, that is specimen A, of diameter 25 millimeters

has no characteristic strength and this is due to the absence of yield point which, in effect, means that the characteristic strength of the bar could not be determined accurately in accordance to the definition of clause 16 BS 4449 and BS 8110 clause 2.3 which says:

" the specified characteristic strength of the steel is the value of the yield stress below which shall fall not more than 5% of the test results of the material complying with this standard".

Samples B,C and D with diameters 20,16 and 12 millimeters respectively, have characteristic strength of 270,355 and 398 N/mm^2 respectively which is below the value 410 N/mm^2 specified by BS 4449 clause 16 (1970) . Samples E and F have characteristic strengths of 444 and 309 N/mm^2 respectively. The provisions made in the BS 4449 allows for a minimum requirement. In other words, if it is intended to verify that the specified characteristic strength is attained by a batch of steel, 10 bars shall be chosen through random sampling, from the batch and tensile test specimen cut from each bar. When such test specimen is subjected to tensile test and found to have a yield stress less than 0.93 of the specified characteristic strength then, that bar shall be rejected. In addition if a test piece from other bars tested has a yield stress less than 0.93 of the specified characteristic strength then the whole batch of steel shall be deemed not to comply with the requirements of the standard. However, where at least 9 results are greater than 0.93 of the specified characteristic

strength the whole batch of steel with the exception of any previously rejected bar,shall be deemed to comply with standard (BS 4449 clause 18).

Thus, samples, A,B and C could be deemed to have failed as each has a characteristic strength below 0.93fy =381.3 N/mm^2. While samples D,E and F have characteristic strength over and above 0.93fy. Although it should however, be observed that the gap existing between the results obtained and the minimum allowed by BS 4449 is very small. Infact, when compared to the most recent standard that is BS 8110: part 1: 1985 section three Table 3.1, which provides the minimum characteristic strength to be 460 and 250 N/mm^2, for high yield steel (hot rolled cold worked)and hot rolled mild steel respectively. Only one bar satisfy the minimum requirement. This bar is sample F with characteristic strength of 309.4 N/mm^2.

In explaining the factors that could be attributed to the apparent failure of these steel specimens to satisfy the minimum requirement, it should be remembered that one of the primary determinant of the quality of steel product is the raw material. That is, the type and chemical composition of the billet. For instance steel grade NSt 37-2 has a carbon content of 0.12-0.17 while Nst 60-2 has 0.35-0.42 as such, they are used for producing different types/sizes of steels.

In other words if a mistake is committed in the process of rolling, so that a wrong billet is chosen for a particular size of bar or the required temperature was not attained, during the

process of rolling, then you can be sure of getting the wrong steel bar. This means it is almost impossible to produce good quality steel without good and adequate quality control.

This brings to mind the role of management, for the HSRC operation manual has clearly show all the quality control procedures and the frequency of such work,right from the time the billets arrived up to the final finishing. However, investigation and annual reports /1/ show that there is sharp reduction in the frequency of quality control activities largely due to the shortage of funds which leads to "Unstable and irregular supply of chemicals and reagents". /1/

Another important factor is source of raw material because in the case of Hadassa steel rolling company, the billets are procured from different sources and most of these sources have different standard. For example, the colour coding varies with the country, and this colour coding is vital to the understanding of the quality and type of billets. For it reveals the chemical composition of such a billet and lack of proper understanding of the colour code may ultimately mean using unknown (wrong) billet for the production of a particular size or type of steel. This will undoubtedly affect the characteristic strength.

Therefore, one may not be surprise if for instance a steel bar of 20mm diameter, which is a high yield steel has characteristic strength of 270 N/mm^2, while another bar has 355 N/mm^2 while mild steel, which ought to be far lower, in terms of strength, has 309.4 N/mm^2/.

In addition, change in the source of raw material in itself, in most cases, do affect the quality as Tremlett /36/ observed that no matter how determined an Engineer is to meet the specification there would always be some variation in the quality of material (product) once they are produced from different places.

5.2.1 Yield strength

TABLE 28: YIELD STRENGTH

SERIAL No.	IDENTIFICATION MARK	AVERAGE YIELD STRENGTH (N/mm^2)
1	A	-
2	B	274
3	C	365
4	D	398
5	E	470
6	F	340

It could be seen from Table 28 sample A has no yield strength. In addition, there was small local contraction at the point of fracture in each of the test pieces both of which indicate a hard material lacking ductility. This result agrees with the ones obtained in the Elongation test (chapter 4) where, this specimen (Sample A) has the lowest percentage elongation with an average of just 16%-only two percent above the minimum as provided by BS 4449. There are some samples having just the minimum allowed (that is, 14 percent). As

Ryder /31/ observed, decrease in the values of Elongation is a clear indication of a "marked falling off in ductility". Meaning that it is brittle.

One could, therefore, observe, that there may have been high carbon content in this specimen A and that explains the absence of the yield point. Which is not the usual characteristic of high yield steel. This, in effect, means that a wrong billet may have been used. On the other hand, it could be that the same bar was re-treaded by passing it through various temperature and pressure thereby reducing its ductility.

From test results, it could also be noted that samples B,C,D,E which are all high yield steel bars, have an average yield strength of 273, 365, 398 and 470. While the only mild steel (sample f) has 340 N/mm^2 which is a low yield strength. This is very inconsistent with the first sample (specimen A). For, there is no difference between the high yield steel and the mild steel in this case. Take the case of sample B and C with average yield strength of 273 and 365 N/mm^2 these are high yield steel bars while sample F, which is a mild steel, has a yield strength of 340 N/mm^2. Infact sample F has higher average yield strength than sample B (with only 273 N/mm^2).

This, again confirms earlier assertion that billet meant for mild steel was used to produce high yield steel. One could say that it is a dangerous production fault in construction industry.

5.2.2 Ultimate strength

TABLE 29: ULTIMATE STRENGTH

SERIAL No.	IDENTIFICATION MARK	AVERAGE ULTIMATE STRENGTH (N/mm^2)
1	2	3
1	A	657
2	B	389
3	C	584
4	D	605
5	E	584
6	F	471

It could be observed from Table 29 above, that samples A, B,C,D and E which are all high yield steels have an average ultimate strength of 657, 389, 584, 605 and 584 N/mm^2 respectively. While samples F which is mild steel have an average ultimate yield strength of 471 N/mm^2. So that all the samples, except one, that are high yield steels have tensile strength above 500 N/mm^2. This clearly show a wide gap between the yield strength (with an average of 300 N/mm^2) and the ultimate tensile strength. That is, a low yield strength and high tensile strength. Though, this is not true for sample B which has an average ultimate strength of 389 N/mm^2.

Samples A of diameter 25 millimeters have the highest value of ultimate strength this means that it is relatively hard thus indicating the fact that the carbon content was high because "carbon always acts as hardener and strengthener, but at the sametime it reduces the ductility" /25/. This coincides

with the previous observations made on the results of the yield strength.

Following some information that the company (HSRC) do provide services to private individuals, one may not rule out the possibilities of these people dictating the "tune of events" as regards to the production process which may affect the quality of the product. At times the machines (rollers) meant for the production of high yield steel may be used for processing billets meant for the production of mild steel. This usually lead to finished product that will definitely appear as high yield steel which, in reality, is not. The only difference between mild steel and high yield steel, at least, to the observer, is the ribs on the high yield steel product.

Moreover, according to the information available /16/ all the product (the high yield steel) of Hadassa steel rolling company (HSRC), are suppose to have a vertical ribs along the length at one metre interval, investigation shows that not all have it. This is a clear manifestation of lack of adherence to production steps, which may be the reason for inconsistency in the quality of the product. Hence the variation in the strength of steel products.

5.2.3 Analysis of yield strength and ultimate strength in relation to clause 17 BS 4449 (1970).

The following Table (30) shows the relationship between the yield strength and the ultimate strength in relation to the provision made in BS 4449: 1970 clause 17.

TABLE 30: YIELD STRENGTH AND ULTIMATE STRENGTH ANALYSIS TABLE

SAMPLE No	DIAMETER [mm]	Yield stress [N/mm^2]	ULTIMATE STRENGTH [N/mm^2]	% ABOVE YIELD STRENGTH
1	25	410*	657	100
2	20	274	389	42
3	16	365	584	60
4	12	398	605	52
5	10	470	584	24
6	10	340	471	39

Usually the ultimate strength should not be more than 15 percent higher than the yield strength. However looking at that above Table, the least percentage above yield strength is 24 which is well above the allowable or minimum value.

*** Sample 1 has no yield strength as such the standard value as provided in Table 5 was used.**

5.2.4 Analysis of Tensile strength in order to determine carbon content

In order to further appreciate the extent of carbon content using the tensile strength obtained from the test, an empirical formula evolved by Rolfe,/32/ which was discussed in chapter two, would be used. This formula is as follows:

$y = 93x + 41/2$

Where : x = carbon content percent

y = Tensile strength in Newton per mm square. The result obtained is set-out in table below.

TABLE 31: CALCULATED CARBON CONTENT

SNo	Identificationon mark	Average tensile	CARBON CONTENT		
			BASED ON ROLFE FORMULA	AS PROVIDED BY BS4449*	ASPROVIDED BY HSRC
1	A	657	0.14	0.25 max.	0.35-0.42
2	B	390	0.08	0.25	0.35-0.42
3	C	584	0.12	0.25	0.35-0.42
4	D	605	0.13	0.25	0.35-0.42
5	E	584	0.12	0.25	0.35-0.42
6	F	471	0.09	0.25	0.12-0.17

* The maximum carbon content may be exceeded by 0.03%.

Thus, it could be seen that there is linear relationship between the tensile strength and the calculated carbon content. However, the calculated carbon content is far below the one given in the technical data sheet prepared by the Hadassa steel rolling company and the one provided by the BS 4449. Because the maximum carbon content based on the calculation is 0.14 percent while the minimum is 0.08 for samples A and B respectively. Which is far less than 0.25 percent as contained in clause 1 BS 4449. This has, again confirm the earlier observation that failure of samples to satisfy the minimum strength as provided by the code may be due to the absence of required amount of carbon which act as a "Strengthener and hardener" of steel.

5.3 Elongation Test

From the test results presented in Tables 21-26, it could be seen that all the samples passed the test, except sample A which, although it has passed the test but the average percentage elongation is 16% that is only 2% over and above the minimum percentage elongation as provided by the standard, that is, BS 4449 of 14%. This is attributed to the absence of yield point as reveal by the tensile test carried out on the same specimen and there was very small local contraction at the point of fracture coupled with the results of the elongation test which shows that it lacks ductility. This further shows the presence of high carbon content and as Raghuwanshi said "hardness varies directly and ductility inversely as the increase in carbon content in steel" /30/.

Furthermore, looking at the whole results, three very important observations could be made:

1. That the percentage elongation is exceptionally high, at least judging from records of test undertaken. This is because the samples C,D,E and F have percentage elongation as high as 60, 75, 66 and 40. This is very disturbing especially considering the fact that all samples, except of course sample F were all high yield steel bars. It is quite unusual to have such high percentage elongation.

This is due to the chemical composition of the steel samples because as it was explained in chapter two, chemical composition greatly affect the behaviour of steel most

especially carbon so that the less the carbon, the high the ductility and the higher the percentage elongation. This is a problem that could haven been avoided, had adequate and careful quality control been carried out at the time of production.

The average percentage of elongation for each diameter is as shown in Table 32.

TABLE 32: AVERAGE PERCENTAGE ELONGATION

SERIAL No.	IDENTIFICATION MARK	AVERAGE PERCENTAGE ELONGATION (%)
1	2	3
1	A	16
2	B	28
3	C	60
4	D	75
5	E	32
6	F	40

2. It is noted, from the results of the elongation test, that the percentage elongation in this work, increase with the decrease in the diameter, with the exception of sample E. For samples A,B,C,D, and E, with diameters 25,20,16,12 and 10 have percentage elongation as follows: 16,28,60,75,and 32. While sample F which is the only mild steel specimen has an average percentage elongation of 40%.

3. That although they are high yield steel bars, but they very much behave like mild steel bars, with the exception of sample

A which has a low percentage elongation this is due to the composition of the steel bars. Absence of required chemical composition automatically changes the behaviour of steel.

During the elongation test, most samples (B-F) failed and necked within the gauge length thus indicating that the samples are of good elongation properties with the exception of sample A- which has a very low percentage elongation. In addition, there was no pronounced necking. This, again, agrees with the result of both the tensile test and elongation test

Finally since sample A has a value of an average of 16 percent which is above the value of 14 percent specified in the code, if follows that increase in carbon content may have been the major problem.

5.4 Bend test

The results in Tables 18 shows sample A with diameter of 25 millimeter fails. This is because after the test, some cracks were observed in the test pieces. However, the remaining samples, that is, sample B,C,D,E, and F all pass the test.

Results of sample A agrees with the observations made on the results of tensile test on sample A. That it is a hard material lacking sufficient ductility. It has not satisfy the ductility requirement. This means that should failure occur, on a reinforced concrete structure that uses this steel reinforcement, there would be no warning time (in the form of say, cracks) only a sudden collapse of structure. Since there

is a linear relationship between carbon content and mechanical qualities; that is the higher the carbon the stronger or harder and the less ductility, one could conclude that the carbon content of sample A is high which leads to such behaviour during the Bend test. This is a clear manifestation of the absence of good and adequate quality control.

5.5 Deviation on cross-sectional area

The deviation on the cross-sectional area and the requirement of the code are shown in Tables 34 to 39.

TABLE 33: DEVIATION ON CROSS-SECTIONAL AREA FOR 25mm DIAMETER BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective C.S.A [mm^2]	Deviation [%]	Max deviation allowed BS 4449 (%)	Remarks
1	2	3	4	5	6	7
1	A-1	491	464	-5.5	± 8	The ratio of effective to cross-sectional area (e/c) = 0.95
2	A-2	491	464	-5.5	± 8	
3	A-3	491	464	-5.5	± 8	
4	A-4	491	464	-5.5	± 8	
5	A-5	491	464	-5.5	± 8	
6	A-6	491	464	-5.5	± 8	
7	A-7	491	475	-3.3	± 8	
8	A-8	491	464	-5.5	± 8	
9	A-9	491	475	-3.3	± 8	
10	A-10	491	475	-3.3	± 8	

The average effective cross-sectional area is 467mm^2 and the

average percentage deviation is -5 percent which is below the maximum of ±8 allowed by BS 4449

TABLE:DEVIATION ON CROSS-SECTION AREA FOR 20mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective C.S.A [mm^2]	Deviation [%]	Max deviation allowed BS 4449 (%)	Remarks
1	2	3	4	5	6	7
11	B-1	314	284	-9.6	±8	Theration of
12	B-2	314	285	-9.2	±8	effective
13	B-3	314	284	-9.6	±8	cross-
14	B-4	314	284	-9.6	±8	sectional
15	B-5	314	285	-9.2	±8	(e/c) = 0.91
16	B-6	314	284	-9.6	±8	
17	B-7	314	284	-9.6	±8	
18	B-8	314	285	-9.2	±8	
19	B-9	314	285	-9.2	±8	
20	B10	314	284	-9.6	±8	

The average effective cross-sectional area is 284mm^ amd the average percent deviation allowed is -9.4 as against the maximum of ±8 allowed by BS 4449.

TABLE 35: DEVIATION ON CROSS-SECTIONAL AREA FOR 16mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective C.S.A [mm^2]	Deviation [%]	Max deviation allowed BS4449 (%)	Remark
1	2	3	4	5	6	7
21	C-1	201	188	-6.5	±8	The ratios of
22	C-2	201	188	-6.5	±8	effective area
23	C-3	201	188	-6.5	±8	to nominal
24	C-4	201	188	-6.5	±8	(e/c) = 0.94
25	C-5	201	188	-6.5	±8	
26	C-6	201	188	-6.5	±8	
27	C-7	201	194	-3.5	±8	
28	C-8	201	194	-3.5	±8	
29	C-9	201	188	-6.5	±8	
30	C-10	201	196	-3.5	±8	

The average percentage deviation is -5.6 compared to the maximum of ±8 allowed by the BS 4449.

TABLE 36: DEVIATIONS ON CROSS SECTIONAL AREA FOR 12mm BAR

Serial No	Identification mark	Nominal C.S.A [mm²]	Effective C.S.A [mm²]	Deviation [%]	Max.Deviation allowed	Remarks
1	2	3	4	5	6	7
31	D-1	113	109	-3.5	±8	e/c = 0.96 satisfy the standard
32	D-2	113	109	-3.5	±8	
33	D-3	113	109	-3.5	±8	
34	D-4	113	109	-3.5	±8	
35	D-5	113	109	-3.5	±8	
36	D-6	113	109	-3.5	±8	
37	D-7	113	109	-3.5	±8	
38	D-8	113	109	-3.5	±8	
39	D-9	113	109	-3.5	±8	
40	D10	113	109	-3.5	±8	

The average percentage deviation is -3.5 as against ±8 maximum deviation while the effective nominal cross-sectional area is 109mm^2, that is 4mm^2 less than the nominal cross-sectional area.

TABLE 37: DEVIATION ON CROSS-SECTIONAL AREA FOR 10mm BAR

Serial No	Identification mark	Nominal C.S.A [mm²]	Effective C.S.A [mm²]	Deviation [%]	max.deviation allowed BS 4449(%)	Remarks
1	2	3	4	5	6	7
41	E-1	78.5	77.3	-1.5	±8	The ratio of effec-tive crosssection to nominal c.s.a (e/c = 0.97)
42	E-2	78.5	75.8	-3.4	±8	
43	E-3	78.5	77.3	-1.5	±8	
44	E-4	78.5	75.8	-3.4	±8	
45	E-5	78.5	77.3	-1.5	±8	
46	E-6	78.5	77.3	-1.5	±9	
47	E-7	78.5	77.3	-1.5	±8	
48	E-8	78.5	75.8	-3.4	±8	
49	E-9	78.5	75.8	-3.4	±8	
50	E-10	78.5	77.3	-1.5	±8	

The average effective cross-sectional area is 76.7mm^2 which is 1.8mm^2 less than the nominal while the average percentage deviations is 2.3 percent as compared to ±8 maximum allowed of BS 4449.

TABLE 38: DEVIATIONS ON CROSS-SECTIOANL AREA FOR 10mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective C.S.A [mm^2]	Deviation [%]	Max. deviation allowed BS 4449	Remarks
1	2	3	4	5	6	7
51	F-1	78.5	75.5	-3.8	±8	The ratio of
52	F-2	78.5	75.5	-3.8	±8	effective
53	F-3	78.5	77	-1.9	±8	cross-section
54	F-4	78.5	75.5	-3.8	±8	area to e/c =
55	F-5	78.5	75.5	-3.8	±8	0.96
56	F-6	78.5	75.5	-3.8	±8	
57	F-7	78.5	75.5	-3.8	±8	
58	F-8	78.5	75.5	-3.8	±8	
59	F-9	78.5	75.5	-3.8	±8	
60	F-10	78.5	75.5	-3.8	±8	

The average effective cross-sectional area is 75.7mm^2 that is, 1.8 percent less than the nominal cross-sectional area and the average percentage deviation is -3.6 percent compared to ±8% maximum allowed by BS 4449.

Deviation on Cross-sectional Area

Almost all the sample satisfy the standard requirement on the deviation on the cross-sectional area, except sample B. These samples, that satisfy the requirement includes A,C,D,E and F of which the ratio of effective cross-sectional area to

nominal cross-sectional area are: 0.95, 0.94, 0.96 and 0.97 respectively. Thus satisfying the maximum deviation allowed by BS 4449 of ±8. However sample B has 0.91 as the ratio of effective cross-sectional area to nominal area (e/c). While the percentage deviation is -9.6 as compared to ±8 allowed by the standard (BS 4449). This also shows that it does not satisfy the standard as it exceed the maximum value allowed.

The nominal cross-sectional area is greater than the measured area, this means that the measured area is small in relation to the expected one. This, again, shows that the bars may have been re-traded confirming the earlier comment made. It also implies that the area assumed in calculation becomes higher than the real measured area, as such, less load would be carried by these steel specimens. This is dangerous to the design life of the structure.

5.6 Deviation on Nominal Mass

Tables 39-44 show the deviations on nominal mass.

TABLE 39: DEVIATION ON NOMINAL MASS FOR 10MM BAR

Serial No	Identification mark	Mass of bar in Kg per metre run Nominal	effective	(%) deviation	Max. deviation allowed by BS 4449 (%).	Remarks
1	2	3	4	5	6	7
41	E-1	0.616	0.607	-1.5	-4	The deviation on nominal mass per metre run satisfy the standard
42	E-2	0.616	0.595	-3.1	-4	
43	E-3	0.616	0.607	-1.5	-4	
44	E-4	0.616	0.595	-3.4	-4	
45	E-5	0.616	0.607	-1.5	-4	
46	E-6	0.616	0.607	-1.5	-4	
47	E-7	0.616	0.607	-1.5	-4	
48	E-8	0.616	0.595	-3.4	-4	
49	E-9	0.616	0.595	-3.4	-4	
50	E-10	0.616	0.607	-1.5	-4	

The difference between nominal and effective is not much just about 0.014 while percentage deviation is less than the max. allowed.

TABLE 40: DEVIATION ON NOMINAL MASS FOR 10mm (MILD STEEL) BAR

Serial No	Identification mark	Mass of bar in Kg per metres run		Deviation (%)	Max.deviation allowed By BS 4449 (%)	Remarks
		Nominal	*Effective*			
1	2	3	4	5	6	7
51	F-1	0.616	0.593	-3.7	-4	
52	F-2	0.616	0.593	-3.7	-4	
53	F-3	0.616	0.604	-3.7	-4	
54	F-4	0.616	0.593	-2.9	-4	
55	F-5	0.616	0.593	-3.7	-4	
56	F-6	0.616	0.593	-3.7	-4	
57	F-7	0.616	0.593	-3.7	-4	
58	F-8	0.616	0.593	-3.7	-4	
59	F-9	0.616	0.593	-3.7	-4	
60	F-10	0.616	0.593	-3.7	-4	

The average effective mass is 0.594 which is 0.022 less than the nominal.

TABLE 41: DEVIATION ON NOMINAL MASS FOR 16mm BAR

Serial No	Identification mark	Mass of bar in Kg per metre run		deviation (%)	Max.deviation allowed by BS 4449 (%)	Remarks
		Nominal	Effective			
1	2	3	4	5	6	7
21	C-1	1.979	1.477	-6.5	-4	The deviation on nominal massper metre run does not
22	C-2	1.579	1.477	-6.6	-4	
23	C-3	1.579	1.477	-6.5	-4	
24	C-4	1.579	1.477	-6.5	-4	
25	C-5	1.79	1.477	-6.5	-4	
26	C-6	1.579	1.477	-6.5	-4	
27	C-7	1.579	1.523	-3.5	-4	
28	C-8	1.579	1.523	-3.5	-4	
29	C-9	1.579	1.474	-6.6	-4	
30	C-10	1.579	1.523	-3.5	-4	

The average percentage deviation is -5.62 as compassed to the maximum deviation allowed by BS 4449 of -4 while the effective mass is 1.343 kg which is 0.24kg less than nominal mass.

TABLE 42: DEVIATION ON NOMINAL MASS FOR 12mm BAR

Serial No	Identification mark	Mass of bar in kg per metre run		Deviation (%)	Max. Deviation allowed by BS 4449 (%)	Remarks
		Nominal	*effective*			
1	2	3	4	5	6	7
31	D-1	0.888	0.857	-3.5	-4	The deviation on nominal mass per metre run satisfy the standard
32	D-2	0.888	0.857	-3.5	-4	
33	D-3	0.888	0.857	-3.5	-4	
34	D-4	0.888	0.857	-3.5	-4	
35	D-5	0.888	0.857	-3.5	-4	
36	D-6	0.888	0.857	-3.5	-4	
37	D-7	0.888	0.857	-3.5	-4	
38	D-8	0.888	0.857	-3.5	-4	
39	D-9	0.888	0.857	-3.5	-4	
40	D-10	0.888	0.857	-3.5	-4	

The average percentage deviation is -3.5 while the maximum deviation allowed by BS 4449 is -4.

TABLE 43: DEVIATION ON NOMINAL MASS FOR 25mm BAR

Serial No	Identification mark	Mass of bar in Kg per-metre run		deviation (%)	Max. deviation allowed by BS 4449 (%)	Remarks
		Nominal	effective			
1	2	3	4	5	6	7
1	A-1	3.854	3.643	-5.5	-4	The deviation on nominal mass per metre run does not satisfy the standard.
2	A-2	3.854	3.643	-5.5	-4	
3	A-3	3.854	3.643	-5.5	-4	
4	A-4	3.854	3.643	-5.5	-4	
5	A-5	3.854	3.643	-5.5	-4	
6	A-6	3.854	3.643	-5.5	-4	
7	A-7	3.854	3.643	-5.5	-4	
8	A-8	3.854	3.643	-5.5	-4	
9	A-9	3.854	3.643	-5.5	-4	
10	A10	3.854	3.643	-5.5	-4	

The difference between mass and effective mass is 0.21kg and the % deviation is -5.5 as compared to the maximum allowed of -4 percent.

TABLE: 44: DEVIATION ON NOMINAL MASS FOR 20mm BAR

Serial No	Identification mark	MASS OF BAR IN KG PER METRE RUN		DEVIATION (%)	Max. Deviation allowed by BS 4449 (%)	Remarks
		nominal	effective			
1	2	3	4	5	6	7
11	B-1	2.466	2.233	-9.4	-4	The deviation on nominal mass per metre run does not satisfy the standard.
12	B-2	2.466	2.237	-9.3	-4	
13	B-3	2.466	2.233	-9.4	-4	
14	B-4	2.466	2.233	-9.4	-4	
15	B-5	2.466	2.233	-9.3	-4	
16	B-6	2.466	2.233	-9.3	-4	
17	B-7	2.466	2.233	-9.4	-4	
18	B-8	2.466	2.233	-9.4	-4	
19	B-9	2.466	2.233	-9.3	-4	
20	B-10	2.466	2.233	-9.4	-4	

The difference between nominal mass and effective mass is 0.23kg and the average percentage deviation is -9.36 as against the maximum allowed of -4 percent.

As it could be seen from above, the first three samples, that is, A, B and C did not satisfy the standard requirement because each has an average percentage deviation of -5.5, -9.36 and -5.62 as against the maximum deviation allowed by BS 4449 which is -4 percent. While D, E and F satisfy the standard as each has an average of -3.5, -2.26 and -3.52 percent deviation which is less than the maximum of -4 percent allowed by BS 4449. Although the difference between the maximum allowed and the values of the percentage deviation of the two of the samples is very small since they (that is, samples D and E) have -3.5 percent each, as deviation on nominal mass.

For the fact that most of these test samples have effective mass per metre-run well below the nominal mass per metre-run, it means that the "quality of matter" is less than the expected or required value. This will undoubtedly affect the strength of steel. As it can be seen the one with highest deviation of 9.36 (Sample B) has the lowest characteristic strength of 270 N/mm^2.

This may, well be attributed to mistake during the production process. Because each of the steel product have separate rollers (machine) for producing such steel and also different raw materials (billets). These rollers are normally replaceable, as such, it is possible to use wrong machine for rolling of a particular steel like the use of machines (rollers) meant for producing high yield steel to process billets that are suppose to be used for mild steel. This would affect or change the properties of such steel. It may also be

attributed to lack of meticulous production control leading to shortage in the required shape and size, hence fall in the mass of such steel.

5.7 Deviation on Nominal Density

The deviation on the nominal density are as given in Tables 45- 50.

TABLE 45: DEVIATION ON NOMINAL DENSITY FOR 25mm BAR

Serial No	Identification mark	Nominal C.S.A[mm^2]	Effective nominal mass [kg/m]	Measured nominal density [kg/mm^2]	Values recommended by standard (min) [kg/mm^2]	Remarks
1	2	3	4	5	6	7
1	A-1	491	3.643	0.0742	0.0785	Values less than
2	A-2	491	3.643	0.0742	0.0785	standard
3	A-3	491	3.643	0.0742	0.0785	recommendation
4	A-4	491	3.643	0.0742	0.0785	
5	A-5	491	3.643	0.0742	0.0785	
6	A-6	491	3.643	0.0742	0.0785	
7	A-7	491	3.643	0.0742	0.0785	
8	A-8	491	3.643	0.0742	0.0785	
9	A-9	491	3.643	0.0742	0.0785	
10	A-10	491	3.643	0.0742	0.0785	

The average measured density is 0.000742 kg/mm^2 5.5 percent less than the value recommended.

TABLE 46: DEVIATION ON NOMINAL DENSITY FOR 20mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective nominal mass [kg/m]	Measured nominal density [kg/mm^2]	Values recommend ed (min) [kg/mm^2]	Remarks
1	2	3	4	5	6	7
11	B-1	314	2.233	0.00711	0.0785	Values less than standard recommen- dation
12	B-2	314	2.237	0.00712	0.0785	
13	B-3	314	2.233	0.00711	0.0785	
14	B-4	314	2.233	0.00711	0.0785	
15	B-5	314	2.237	0.00712	0.0785	
16	B-6	314	2.237	0.00712	0.0785	
17	B-7	314	2.233	0.00711	0.0785	
18	B-8	314	2.233	0.00711	0.0785	
19	B-9	314	2.237	0.00711	0.0785	
20	B-10	314	2.233	0.00711	0.0785	

The average measured density is 0.000711 kg/mm^2, 9.43 percent less than the minimum value recommended by the standard.

TABLE 47: DEVIATION ON NOMINAL DENSITY FOR 16mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective C.S.A [mm^2]	Measured nominal density [kg/mm^2]	Values recommended (min) [kg/mm^2]	Remarks
1	2	3	4	5	6	7
21	C-1	201	1.477	0.0735	0.0785	Values less than standar d recomme n- dation
22	C-2	201	1.474	0.0734	0.0785	
23	C-3	201	1.477	0.0735	0.0785	
24	C-4	201	1.477	0.0735	0.0785	
25	C-5	201	1.477	0.0735	0.0785	
26	C-6	201	1.477	0.0735	0.0785	
27	C-7	201	1.523	0.0758	0.0785	
28	C-8	201	1.523	0.0758	0.0785	
29	C-9	201	1.474	0.0734	0.0785	
30	C-10	201	1.523	0.0758	0.0785	

The average measured nominal density is 0.00742 kg/mm^2, 5.5 percent less than the minimum value recommended.

TABLE 48: DEVIATION ON NOMINAL DENSITY FOR 12mm BAR

Serial No	Identification mark	Nominal C.S.A[mm^2]	Effective C.S.A [mm^2]	Measured nominal density [kg/mm^2]	Values recommended(min) [kg/mm^2]	Remarks
1	2	3	4	5	6	7
31	D-1	113	0.857	0.0759	0.785	Values less than standard recommendation.
32	D-2	113	0.857	0.0759	0.785	
33	D-3	113	0.857	0.0759	0.785	
34	D-4	113	0.857	0.0759	0.785	
35	D-5	113	0.857	0.0759	0.785	
36	D-6	113	0.857	0.0759	0.785	
37	D-7	113	0.857	0.0759	0.785	
38	D-8	113	0.857	0.0759	0.785	
39	D-9	113	0.857	0.0759	0.785	
40	D-10	113	0.857	0.0759	0.785	

The average measured density is 0.0076 kg/mm^2, 3.2 percent less than the recommended minimum value.

TABLE 49: DEVIATION IN NOMINAL DENSITY FOR 10mm BAR

Serial No	Identification mark	Nominal C.S.A [mm^2]	Effective Nominal mass [kg/m]	Measured nominal density [kg/mm^2]	Value recommended by standard (min) [kg/mm^2]	Remarks
1	2	3	4	5	6	7
41	E-1	78.5	0.607	0.0077	0.0785	Values less than standard recommendation
42	E-2	78.5	0.595	0.0076	0.0785	
43	E-3	78.5	0.607	0.0077	0.0785	
44	E-4	78.5	0.595	0.0076	0.0785	
45	E-5	78.5	0.607	0.0077	0.0785	
46	E-6	78.5	0.607	0.0077	0.0785	
47	E-7	78.5	0.607	0.0077	0.0785	
48	E-8	78.5	0.595	0.0076	0.0785	
49	E-9	78.5	0.595	0.0076	0.0785	
50	E-10	78.5	0.607	0.0077	0.0785	

The average measured nominal density is 0.0077 kg/mm^2; 2 percent less than the minimum value recommended by standard.

TABLE 50: DEVIATION ON NOMINAL DENSITY FOR 10mm MILD STEEL BAR

SERIAL No	IDENTIFICATION MARK	NOMINAL C.S.A. [mm^2]	EFFECTIVE NOMINAL MASS [Kg/mm^2]	MEASURED NOMINAL DENSITY [Kg/mm^2]	VALUES RECOMMENDED BY STANDARD (min) [Kg/mm^2]	REMARKS
1	2	3	4	5	6	7
51	F-1	78.5	0.593	0.0076	0.00785	Values less than standard recommen-dation.
52	F-2	78.5	0.593	0.0076	0.00785	
53	F-3	78.5	0.604	0.0076	0.00785	
54	F-4	78.5	0.593	0.0076	0.00785	
55	F-5	78.5	0.593	0.0076	0.00785	
56	F-6	78.5	0.593	0.0076	0.00785	
57	F-7	78.5	0.593	0.0076	0.00785	
58	F-8	78.5	0.593	0.0076	0.00785	
59	F-9	78.5	0.593	0.0076	0.00785	
60	F-10	78.5	0.593	0.0076	0.00785	

The average measured density is 0.0076 kg/mm^2, 3.2 percent less than the recommended minimum value.

All the first three samples in the batch failed to meet the values recommended by the standard just like the case of nominal mass. This indicates that they were not as dense as they ought to be.

The remaining three samples D,E and F have values close to the value recommended by the British standard BS 4449. although they are also below the recommended value as such they are deemed to have failed. For, they have 0.00759, 0.0077 and 0.0076 kg/mm^2 measured nominal density for D,E and F respectively as compared to the value recommended by the standard, which is approximately 0.008 kg/mm^2. These samples D,E and F fall short of the recommended value by approximately 3.3, 2.0 and 3.2 percent. While the first three samples fall by 5.5, 9.43 and 5.5 percent short of the minimum value recommended by standard.

On the whole, all the samples have measured nominal density below the values recommended by standard BS 4449. However, those with values less than 8 percent, could be accepted. This behaviour of not satisfying the standard value may be attributed to the absence of the required chemical constituents in these steel thus affecting the quality of steel. The chemical test was not carried out because no equipment and chemical available.

Samples B has average measured density of 0.00711 kg/mm^3, which is 9.43 percent less than the minimum recommended value of 0.00785, the characteristic strength of the same sample is very low which is $270N/mm^2$. Likewise sample C is 5.5 percent less than the minimum value, it has $355N/mm^2$ characteristic strength for below the recommended value of 410 N/mm^2. On the other hand sample E has an average measured density is $0.0077kg/mm^2$ which is just 2 percent below the minimum value

this same sample has characteristic strength of 443.6 N/mm^2.

All these, shows lapses in the production process thereby affecting the quality of the product.

5.8 Specific Gravity

The values of the specific gravity of the steel samples are shown in Tables 51 to 56.

TABLE 51: DEVIATION ON SPECIFIC GRAVITY FOR 25mm BAR

Serial No	Identification mark	Weight (kg)		Specific gravity	Recommended value (min) by standard	Remarks
		In air	*in water*			
1	2	3	4	5	6	7
1	A-1	1530	1330	7.65	7.85	Values less than standard recommendation
2	A-2	1530	1330	7.65	7.85	
3	A-3	1530	1330	7.65	7.85	
4	A-4	1530	1330	7.65	7.85	
5	A-5	1530	1330	7.65	7.85	
6	A-6	1530	1330	7.65	7.85	
7	A-7	1550	1340	7.65	7.85	
8	A-8	1530	1330	7.65	7.85	
9	A-9	1550	1345	7.65	7.85	
10	A-10	1550	1345	7.65	7.85	

The average value of specific gravity is 7.65, 0.2 short of the recommended value. About 2.6 percent less than the Value.

TABLE 52: DEVIATION ON SPECIFIC GRAVITY FOR 20mm BAR

Serial No	Identification mark	Weight (kg)		Specific gravity	Recommended value (Min) by standard	Remarks
		In air	*in water*			
1	2	3	4	5	6	7
11	B-1	960	832	7.50	7.85	Values less than standard recommendation .
12	B-2	962	835	7.57	7.85	
13	B-3	960	831	7.44	7.85	
14	B-4	960	831	7.44	7.85	
15	B-5	961	832	7.45	7.85	
16	B-6	962	835	7.47	7.85	
17	B-7	960	832	7.50	7.85	
18	B-6	960	832	7.50	7.85	
19	B-9	962	835	7.57	7.85	
20	B-10	960	831	7.44	7.85	

The average value of specific gravity is 7.5, approximately 5 percent less than the reaccommodate value.

TABLE 53: DEVIATION ON SPECIFIC GRAVITY FOR 16mm BAR

Serial No	Identification mark	Weight (kg)		Specific gravity	Recommended value (min) by standard	Remarks
		In air	*in water*			
1	2	3	4	5	6	7
21	C-1	635	550	7.47	7.85	Values less than standard recommen-dation.
22	C-2	634	550	7.54	7.85	
23	C-3	635	550	7.47	7.85	
24	C-4	635	550	7.47	7.85	
25	C-5	635	545	7.06	7.85	
26	C-6	635	545	7.06	7.85	
27	C-7	655	565	7.28	7.85	
28	C-8	655	565	7.28	7.85	
29	C-9	634	550	7.54	7.85	
30	C-10	655	560	7.00	7.85	

The average value of specific gravity is 7.32 which is 6.75 percent less than the recommended value.

TABLE 54: DEVIATION ON SPECIFIC GRAVITY FOR 12mm BAR

Serial No	Identification mark	Weight (kg)		Specific gravity	Recommended value (min) by standard	Remarks
		In air	In water			
1	2	3	4	5	6	7
31	D-1	360	310	7.20	7.85	Values less than standard recommendation.
32	D-2	360	315	8.20	7.85	
33	D-3	360	310	7.20	7.85	
34	D-4	360	310	7.20	7.85	
35	D-5	360	315	8.20	7.85	
36	D-6	360	310	7.20	7.85	
37	D-7	360	310	7.20	7.85	
38	D-8	360	310	7.20	7.85	
39	D-9	360	310	7.20	7.85	
40	D-10	360	310	7.20	7.85	

The average of specific gravity is 7.36, that is, 0.49 less than the recommended value (about 6.24 percent).

TABLE 55: DEVIATION ON SPECIFIC GRAVITY FOR 10mm BAR

Serial No	Identification mark	Weight (kg)		Specific gravity	Recommended value (min) by standard	Remarks
		In air	*In water*			
1	2	3	4	5	6	7
41	E-1	255	220	7.24	7.85	Values less than standard recommendation.
42	E-2	250	215	7.14	7.85	
43	E-3	255	210	7.24	7.85	
44	E-4	250	215	7.14	7.85	
45	E-5	255	211	7.50	7.85	
46	E-6	255	211	7.50	7.85	
47	E-7	255	212	7.72	7.85	
48	E-8	250	215	7.14	7.85	
49	E-9	250	215	7.14	7.85	
50	E-10	255	210	7.29	7.85	

The average specific gravity is 7.31 approximately 7 percent lower than the recommended value.

importance to both life and quality of structures in construction industry. As a results of lapse in management as well as quality control, accident can occur in construction site. Thus thorough and high skilled management cannot be over-emphasized in an industry such as this.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on the test results, discussions and analysis, the following conclusions are made:

1. All the samples in the batch with the exception of E and F failed to satisfy the standard requirement on characteristic strength as contained in BS 4449 clause 17. Because samples B,C and D have 270, 355 and 398/Nmm^2 respectively, as their characteristic strength.

2. Samples E and F met the standard requirement on characteristic strength with a value of 444 and 309 N/mm^2 respectively as compared to 410 and 250 N/mm^2 respectively required by the BS 4449 clause 17.

3. If clause 16. 2.2 of BS 4449:1969 is taken into consideration, bars D,E and F with characteristic strength of 398, 444 and 309 N/mm^2 could be deemed to have satisfy this provision of the standard as they have 0.93 of specific characteristic strength.

4. However, if BS 8110: part 1: 1985 section three, Table 3.1, is considered, then all the high yield steel bars failed, since they have characteristic strength below 460 N/mm^2 as contained in the above mentioned standard. But the last

sample, which is mild steel has satisfy the standard since it has characteristic strength of 309 N/mm^2 as against 250 N/mm^2 provided in the BS 8110.

5. Most samples, for example, B,C,D,E,and F have passed the elongation test with a high percentage elongation which is inconsistent with the behaviour of high yield steel. Except sample A which has very low percentage elongation, some of which are within the margin of the minimum allowed by BS 4449 clause 17 Table 5.

6. Samples B,C,D,E and F passed the Bend test as there was no cracks observed during the test on these samples. While sample A of 25 millimeters diameter failed the test as cracks were observed during the test.

7. All test samples fail to meet the standard requirement for the least value of measured density. Because test samples A,B,C,D,E and F have an average measured density of 0.00742, 0.007111, 0.00742, 0.00759, 0.0077 and 0.0076 kg/mm^2 respectively as compared to the recommended minimum value of 0.00785.

8. Samples A,B,and C, with effective mass of 3.643, 2.236 and 1.343 did not satisfy the standard requirement on deviation on nominal mass as provided in clause 11, Table 3, BS 4449; as the above value represent -5.5, -9.36 and -5.62 percent deviations as compared to the minimum value

of -4. The value of the recommended value of the nominal mass per metre-run as contained in the BS 4449 are: 3.854, 2.466, 1.579, 0.888 and 0.616 for diameters of 25, 20, 16, 12 and 10 respectively.

Samples D,E and F which are smaller diameters, with average effective mass of 0.867, 0.602 and 0.594 kg respectively have -.3.5, -2.3 and -3.6 percent short of the required value, they could be deemed to have fall within the recommended value of -4 percent.

Though in reality, one could conclude that only sample E passed, D and F are very close to -4 percent.

9. All samples could be deemed to have failed the specific gravity requirement because samples A,B,C,D,E and F have 7.62, 7.36, 7.31 and 7.52 respectively as compared to the recommended value of 7.85.

10. Most samples have passed the maximum deviation on cross-sectional area allowed by standard BS 4449 clause 11.2.3 as samples A,C,D,E and F have average effective cross-section area of 467, 190, 109, 76.7 and 75.7mm^2 respectively this represents, average percentage deviation of -5, -5.6, -3-5, -2.3, and 3.6 which is not up to the maximum deviation of ±8 percent. So they could be regarded as having passed the test.

Except sample B which has an average percentage deviation of -9.4 percent.

11. Judging from the results of test undertaken, most especially tensile and bend test, there is no difference between the high yield steel and mild steel. For example sample B and C are high yield steel bars, but they have 270 and 355 N/mm^2 as their respective characteristic strength. While sample F, a mild steel, has characteristic strength of 309.4N/mm^2. The percentage elongation for B and C are 28 and 60 percent. While that of sample F is 40 percent.

12. From the records of production as contained in Table 8 and taking into consideration the results of test, one could say that the bars that are mostly used in the construction industry (like 25, 20, 16) failed most of the test.

13. From the results and discussions there is no adequate quality control being undertaken.

14. From the field work, carried out, it was observed that:-

a. The cost of steel produced by the company is very expensive as the production cost is excessive because of the distance between the source of raw material and the company.

b. The company uses raw materials from different sources some from Delta steel company some from overseas.

15. Management should endeavour to give enough funds to the quality control section so as to ensure the production of steel of high quality. All procedures for checking and testing billets and finished products, as contained in company's manual for operation should be followed carefully and strictly.

16. Effort should be made towards the implementation of the recommendation made by expert on the expansion of the company so that it would no longer be dependent on the document of the billets.

17. There is the need for the Council for the Regulation of Engineering in Nigeria, Nigerian Society of Engineers and possible Nigerian Industrial Organisation to make an independent evaluation of the quality of steel product from time-to-time and to put a halt on the use of some of the provision of British Standard and instead, they should come-up with a viable alternative.

18. All steel companies should use a unified or single standard of specifications and testing of their products. The above named bodies that is COREN, NSE and NIS should see to it that the testing is done as it should, with periodic calibration and testing observed by these bodies. It should be Nigerianised to serve our needs.

19. There should be proper motivation of workers and such incentive should be tied to productivity (out put) and profit.

20. Judging at the result of the test undertaken, designers (or structural engineers) must be careful where this steel is to be used, in deciding the type and number of bars to be used in a particular section. All steel must be tested.

6.2 RECOMMENDATION

1. The Federal government and the management of the said company should make serious and very sincere effort to address the problems militating against the supply of sufficient raw materials (billets), This can be done by making sure that sufficient billets from Ajaokuta steel company or Delta steel company through railways.

2. Proper inspection of billets procured should be carried before use. Such exercise must begin right from the company where the billets were produced before lifting them to the company. There should be no reservation about the quality of the billets.

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