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Chemical Analysis of Steel Reinforcing Bars: Case Study of South – West, Nigeria

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Abstract: The chemical constituents of steel rebar brands have actually revealed the deficiencies and level of impurities in both the local and imported steel for concrete works. Setting a point of reference for the applicability of building material particularly the steel reinforcement, besides investigation on the short-term and long-term behaviour of locally manufactured reinforcement bars are very imperative to safeguard the integrity of existing and new structure. To eradicate frequent collapse of building that result into unexpected loss of lives and investment as a result of catastrophic structural failure, thorough evaluation of material properties cannot be underemphasized. Investigations have shown that building components tend to fail at different rates depending on quality of materials, designs and construction method, environmental conditions and the use of the building. However, substandard materials and design errors were identified as to major causes of component or element failures. The specific causes of failure of building components, aside substandard materials and design errors, revolve round the construction method and the component materials.Thus, there is need to carried out research on the chemical constituents of steel rebar types so as to know the level of deficiencies and impurities in order to create a window for stakeholders such as research, academics, industry and regulatory agencies, through which fundamental problems could and should be addressed.

1. INTRODUCTION

Reinforced concrete, as the most extensively used construction material, plays a vital role in worldwide economic evolution and infrastructural development (Bellis2011; Hashemi2006). In actual fact, reinforced concrete constitutes aboveninety percent (90%) of infrastructure systems in developing nations (Erhard 2006; Castro et al. 2002), while despite the progresses in emerging technologies as well as innovative materials, not more thanseventy-five (75%) of constructed amenities in the industrialized countries (Basu et al. 2004; Kankam and Adon-Asamoah2002). The setups of civil infrastructure as well as constructed amenitiesfor examplesdams and retaining wall,bridges, tunnels,buildings, transportation systems, water resources, nuclear power plants, telecommunications installations and wastewater systems, besides other life-supporting amenitiesaidin deliveringof structural foundations, critical services, provision of shelter, sustenanceof social interfaces and economic improvement (Chahrour and Soudki2005; Kayali and Zhu 2005; Kosmatka et al. 2003). For all intents and purposes, the sustainable economic evolution, productivity, and the welfare of a countryhang cripplingly on the durability, functionality and reliability of its civil infrastructure structures (Kaushik and Singh 2002; Logan 2000). Rebars are rolled from billets that are acquired from a blast furnace. Billets can be manufactured either from iron-ore thru the blast furnace converter path, or via melting scraps then refining the same in the furnace (Phillips 1998; Clifton and Marthey1983). Nigeria major steel companies produced steel from raw materials either as finished products or steel billet which are semi-finished products (Bellis2011; Basu et al. 2004; Phillip 1998). In addition, the steel reinforcing rebar required for structural concrete is partiallymanufactured by the country's inland rolling mills whereas the balance is obtainedfrom importation. The importation is performed mostly by private industrialists, but the quality of such imported steel bar product is not always surefire as they are principally brought in from various sources without any comprehensive standardization procedure regarding their structural properties (Edward 2006; Hashemi2006; Logan 2000). Thus, differences are inevitable to arise in the strengths, besidesfeasibly, steel geometry assumed in design and those utilized for real construction, except tests are performed on every set of imported steel supplied on construction site. Conclusively, with the near collapse of the government-owned rolling mills as well assubsiding performance of the privatized counterparts in an unfriendly economy, influx of reinforcement bars from uncertain sources are the order of the day in Nigerian marketplaces.

2. METHOD

The method used in carrying out this research work is field survey and laboratory tests. The field survey involves visiting the companies so as to obtained samplings used in this researchwhich were 10mm, 12mm, 16mm, 20mm and 25mm diameter reinforced steel bars. Three specimens each of 750mm length were collected with the aid of Vernier caliper on each of the diameter. These samplings were obtained from two main sources (local and imported steel bars). This is necessary for proportionalanalysis as well as scrutiny. The locally manufactured reinforced steel bars were obtained from six steel industries (Major, Federated,

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Sun hannan, LCI, Pulkit and Top), whereas imported steel bars was obtained Ukraine company.

This specifies that seven (7) samplings were obtained from each companies and a total of twenty-onesamplings including imported steelrebars were taken to the laboratory for analyses. Arc Spectrometer (AS) was used for chemical analysis of the samplings. The experimentation was carried out via placing the grinded sampling under the Arc spectrometer, after calibrated the machine and the reading begins from zero.

3. RESULTS AND DISCUSSION

One option of sampling of steel rebars was to obtain the bar samples from the major steel industries and major importing companies of steel bars. Hence, this study opted for the most commonly bought bar types for civil and building construction works for a more reasonable judgment. The chemical analysis of the most commonly used imported and local steel reinforcing steel bar samples was carried out at the Metallurgical Laboratory of University of Lagos, Lagos, Nigeria. The average values of the results obtained from a specimen of five samples were analyzed for twenty-six (26) chemical constituents using Optical Emission Spectrometry method and five of these constituent values were compared with ASTM A706/A706M (2013), BS 4449 (2001) and Nigerian Standard NST-65-Mn as presented in Figure 1-6.

The steel bars experimented were obtained from imported and local sources. This is imperative for comparative investigation and analysis. Most steel rebars imported into Nigeria are majorly from Ukraine. The locally produced rebars were obtained from six sources mostly based in Lagos State. They predominantly use scraps as their major raw materials for producing steel. These industries are Major, Federated, Sun Hassan, LCI, Pulkit, and Top. Typical chemical ingredients that have essential controlling influence on the properties of steel rebars were extracted from Figures 1-6 for easy graphical comparison with applicable standards.

3.1 Carbon

The carbontest value using both local and imported (Ukraine) steel rebars are presented in Figure 1.

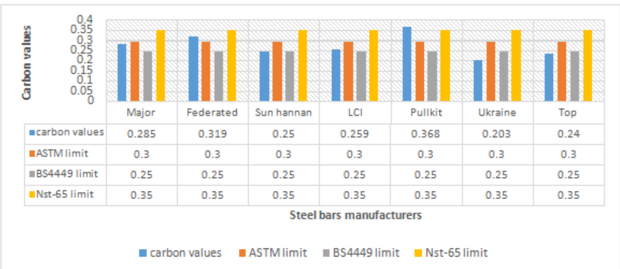

Figure 1. *Carbon values and reinforcement bars producers.*

Figure 1 reveals each carbon values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449).Imported steel bar (Ukraine) produce carbon contents that fall within the NST-65-Mn, ASTM A706 and BS 4449 with specifications of 0.35%, 0.3% and 0.25% maximum values respectively.Only Pilkit steel satisfied the three international standard. Whereas, Federated meet the requirement of BS 4449 (2001) and ASTM. All theremaining locally manufactured steel bars except Top steel, have carbon contents between 0.250 – 0.368% and satisfied BS 4449 (2001). Carbon is the cheapest and the most effective alloying element for hardening iron. Higher carbon contributes to the tensile strength of steel for higher load bearing capacity. Much lower carbon content of less than 0.1% will reduce strength, while higher carbon content of 0.3% and above makes the steel bars unweldable and brittle (Basuet al. 2004; Kankam and Adom-Asamoah2002). It is therefore evident that the strength of Federated and Pulkit steel specimens were enhanced at the expense of weldability and ductility.

3.2 Silicon

The silicontest value using both local and imported (Ukraine) steel rebars are presented in Figure 2.

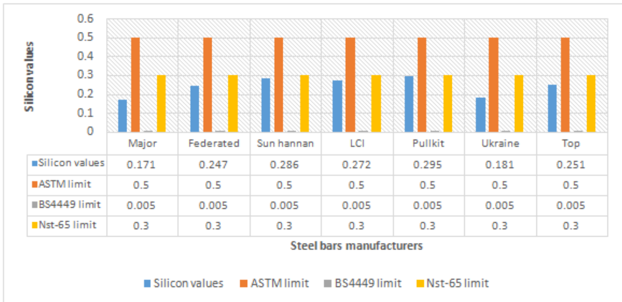

Figure 2. *Silicon values and reinforcement bars producers.*

Figure 2 indicates the trend for each silicon values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449).The requirements for silicon were satisfied by the NST-65-Mn and ASTM A706 with limiting values of 0.3% and 0.5% respectively. All the steel rebars, local or imported, manufactured from the investigated sources are within the stipulations.

3.3 Phosphorus

The phosphorustest value using both local and imported (Ukraine) steel rebars are presented in Figure 3.

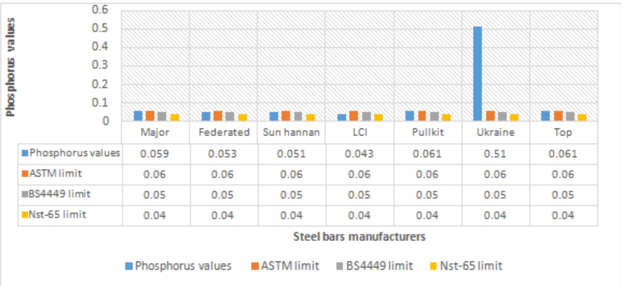

Figure 3. *Phosphorus values and reinforcement bars producers.*

Figure 3 discloses each Phosphorus values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449). The maximum limits mostly suggested by major international standards are in the range 0.04 – 0.06%. It is noticeable from Figure 3 that all the samplings were at the upper limits, whichsuggesting the presence of impurities. On the other hand, the Ukraine imported brand had extremely high phosphorous content signifying much higher impurities than other samples.The wrong way round, phosphorous content is often present as an impurity which increases brittlenessand strength. Because higher phosphorous content contributes to the increase in strength and corrosion resistance properties, but brings brittleness as a result of formation of low euctoidphosphicles in the grain boundary (Kayali and Zhu 2005; Kaushik and Singh 2002; Kankam and Odum-Ewuakye2001).

3.4 Sulphur

The sulphurtest value using both local and imported (Ukraine) steel rebars are presented in Figure 4.

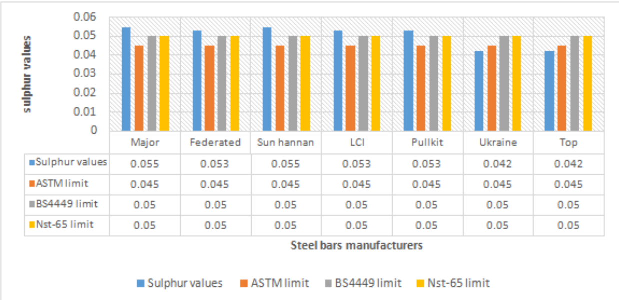

Figure 4. *Sulphur values and reinforcement bars producers.*

Figure 4 shows the trend for each sulphur values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449). It is evident from Figure 4 that the entire steel bar specimens examined except those from Pulkit and Ukraine exceeded all the required limits. In fact, Pulkit and Ukraine did not meet NST-65-Mn limit, but were within the other specified limits.Presence of sulphur is limited to a maximum value of 0.045%, 0.050% and 0.040% for ASTM A706, BS 4449 and NST-65-Mn respectively. Sulphur indicates the presence of impurity in steel which in turn increases impurity. The presence of higher sulphur content makes the bar brittle during twisting, since higher sulphur content brings the hot shot difficulties during rolling (Maghsoudi and Akbarzadeh2006; Kaushik and Singh, 2002; Clifton et al. 1999).

3.5 Copper

The coppertest value using both local and imported (Ukraine) steel rebars are presented in Figure 5.

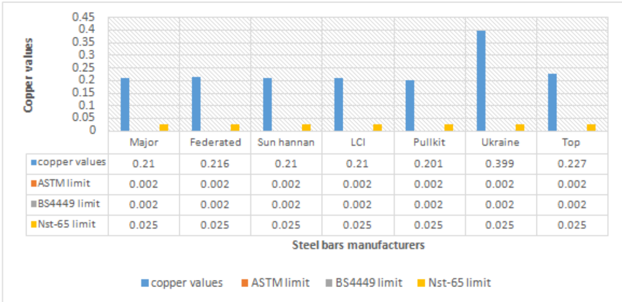

Figure 5. *Copper values and reinforcement bars producers.*

Figure 5 reveals each copper values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449). Figure 5 clearly shows that all the steel samples investigated far exceeded the 0.025% limit.Copper is a pearlite stabilizer that increases the strength and corrosion resistance property of the reinforcing bars. NST-65-Mn limits copper content in steel rebars to 0.025%, while just 0.002 or no specific limit found for other international standards.

3.6 Manganese

The manganesetest value using both local and imported (Ukraine) steel rebars are presented in Figure 6.

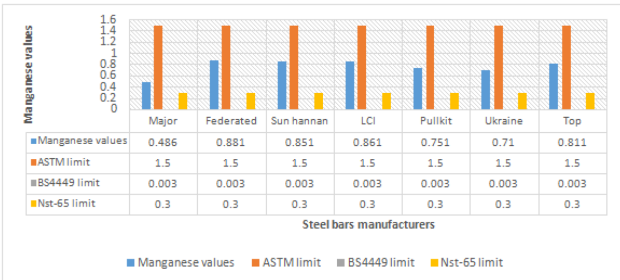

Figure 6. *Manganese values and reinforcement bars producers.*

Figure 6 indicates the trend for each silicon values, the steel bars producers with international standard (NST-65-Mn, ASTM A706 and BS 4449). Though, all the steel specimens were much lower than the maximum specified values.Manganese maximum content in steel of 1.5% and 1.6% are specified by ASTM A706 and NST-65-Mn respectively. Since higher manganese content in steel increases the tensile strength and also

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the carbon equivalent property (Basuet al. 2004; Neville and brooks 1994), it can be inferred that the tensile strengths of these specimens are more likely not to be extremely enhanced.

4 CONCLUSION

The chemical analyses of the steel samples revealed that the imported steel samples from Ukraine yield carbon contents that fall within the NST-65-Mn, ASTM A706 and BS 4449 with specifications of 0.35%, 0.3% and 0.25% maximum values respectively. Only Pilkit steel satisfied the three international standard. Whereas, Federated meet the requirement of BS 4449 and ASTM. All theremaining locally manufactured steel bars except Top steel, have carbon contents between 0.250 – 0.368% and satisfied BS 4449. It is therefore obvious that the strength of Federated and Pulkit steel specimens were enriched at the expense of weldability and ductility. All the steel rebars, local or imported, produced from the investigated sources are within the specifications for silicon. All the steel samplings were much lesser than the maximum specified values for Manganese. The tensile strengths of these specimens are more likely not to be extremely enhanced. The phosphorous contents of all the samplings were greater than the maximum limits signifying the presence of impurities. All steel samplings except those from Pulkit and Ukraine exceeded all maximum sulphur limits of major international standards. Further analysis, reveals all the steel rebarsbrands(local and imported) far exceeded the 0.025% limit of copper content. It can be concluded that virtually all the steel types contained different degrees of impurities.

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