Data Article

Dataset on the evaluation of chemical and mechanical properties of steel rods from local steel plants and collapsed building sites

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Abstract

The quality of steel rods used in structural applications has been subjected to continuous scrutiny by researchers in Nigeria. In this data article, the experimental data on the chemical and mechanical properties of steel rods from collapsed building sites and local steel plants have been reported. The chemical composition consisting of carbon, manganese, silicon, sulphur, phosphorus among other elements were recorded using an optical emission spectrometer. Some of the main elements were used to evaluate the carbon equivalent value and the results are reported in this article. The yield strength, ultimate tensile strength and percentage elongation were also presented as obtained from the universal testing machine. The hardness values of the steel rod samples were also presented.

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**Value of the data**

- The data provide information on the utilization of scraps as a raw material in the production of reinforcing steel rods.
- The reported data reveal the chemical and mechanical properties of steel rods from local plants and collapsed sites and this will serve as bases for further study on reinforcing steel bars produced from scraps and their contributions to collapse of building structures.
- The data presented are useful to construction Engineers within the country when selecting steel rods for structural reinforcement.

1. Data

The data presented information on the chemical compositions, carbon equivalent value (CEV), yield strength (YS), ultimate tensile strength (UTS), hardness value and percentage elongation of steel rods (different diameters) from collapsed building sites, and local plants. The chemical (elemental) compositions of the steel rods are presented in Table 1 containing carbon (C), silicon (Si), manganese (Mn), sulphur (S), and phosphorus (P) among others. Table 2 shows the yield strength (YS), while Table 3 represents the ultimate tensile strength (UTS) of the steel rod samples. The percentage elongation of the steel rod samples are also presented in Table 4. Table 5 shows the carbon equivalent and the hardness values for the steel rod samples.
### Table 1
Elemental (Chemical) composition of the steel rod samples.

| Element (%) | Samples |  |  |  |  |  |  |  |  |  |
|-------------|---------|---|---|---|---|---|---|---|---|---|
|             | EA      | IA | SA | OA | AA | ALA | A12 | A16 | B10 | B12 | B16 |
| C           | 0.339   | 0.311| 0.345| 0.324| 0.351| 0.315| 0.259| 0.329| 0.330| 0.169| 0.291|
| Si          | 0.231   | 0.223| 0.206| 0.222| 0.23 | 0.216| 0.179| 0.176| 0.307| 0.228| 0.193|
| S           | 0.080   | 0.086| 0.079| 0.018| 0.049| 0.063| 0.038| 0.036| 0.040| 0.047| 0.042|
| P           | 0.069   | 0.079| 0.068| 0.075| 0.067| 0.056| 0.043| 0.042| 0.045| 0.056| 0.054|
| Mn          | 0.983   | 0.991| 0.806| 1.001| 0.963| 0.981| 0.519| 0.555| 0.727| 0.579| 0.579|
| Ni          | 0.106   | 0.107| 0.110| 0.112| 0.121| 0.123| 0.100| 0.112| 0.091| 0.085| 0.105|
| Cr          | 0.223   | 0.223| 0.225| 0.212| 0.220| 0.205| 0.154| 0.164| 0.163| 0.204| 0.271|
| Mo          | 0.030   | 0.030| 0.031| 0.023| 0.031| 0.032| 0.028| 0.023| 0.027| 0.030| 0.025|
| V           | 0.006   | 0.006| 0.006| 0.005| 0.005| 0.048| 0.005| 0.004| 0.004| 0.005| 0.004|
| Cu          | 0.283   | 0.284| 0.282| 0.281| 0.283| 0.281| 0.342| 0.261| 0.245| 0.292| 0.308|
| W           | 0.012   | 0.012| 0.011| 0.013| 0.011| 0.012| 0.010| 0.013| 0.015| 0.012| 0.011|
| Ti          | 0.002   | 0.002| 0.002| 0.002| 0.002| 0.002| 0.001| 0.002| 0.003| 0.001| 0.003|
| Sn          | 0.016   | 0.016| 0.015| 0.013| 0.016| 0.017| 0.014| 0.015| 0.017| 0.016| 0.013|
| Co          | 0.011   | 0.011| 0.011| 0.012| 0.011| 0.012| 0.010| 0.014| 0.013| 0.011| 0.011|
| Al          | 0.006   | 0.003| 0.004| 0.005| 0.005| 0.003| 0.021| 0.021| 0.021| 0.020| 0.021|
| Nb          | 0.001   | 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.001| 0.002| 0.001|
| Fe          | 97.602  | 97.615| 97.618| 97.681| 97.634| 97.634| 98.273| 98.236| 97.950| 98.241| 98.068|

### Table 2
Yield strength of the steel rod samples.

| YS (N/mm²) | Sample 1 | Sample 2 | Sample 3 | Average |
|------------|----------|----------|----------|---------|
| EA         | 460.16   | 458.12   | 462.15   | 460.14  |
| IA         | 488.11   | 488.56   | 482.28   | 486.32  |
| SA         | 550.66   | 552.01   | 552.02   | 551.56  |
| OA         | 493.21   | 491.06   | 492.04   | 492.10  |
| AA         | 468.04   | 467.20   | 466.56   | 467.27  |
| ALA        | 466.94   | 465.98   | 467.91   | 466.94  |
| A12        | 406.10   | 406.63   | 404.34   | 405.69  |
| A16        | 389.04   | 388.19   | 387.12   | 389.12  |
| B10        | 410.89   | 409.92   | 410.96   | 410.59  |
| B12        | 406.44   | 404.98   | 402.44   | 404.62  |
| B16        | 373.04   | 372.15   | 374.21   | 373.13  |

### Table 3
Ultimate tensile strength of the steel rod samples.

| UTS (N/mm²) | Sample 1 | Sample 2 | Sample 3 | Average |
|-------------|----------|----------|----------|---------|
| EA          | 598.88   | 596.28   | 596.48   | 597.21  |
| IA          | 586.53   | 585.86   | 584.92   | 585.77  |
| SA          | 625.39   | 628.13   | 623.74   | 625.75  |
| OA          | 556.55   | 556.76   | 556.98   | 556.76  |
| AA          | 545.69   | 545.74   | 545.44   | 545.62  |
| ALA         | 577.48   | 578.55   | 576.22   | 576.42  |
| A12         | 584.00   | 581.28   | 582.03   | 582.44  |
| A16         | 590.06   | 592.00   | 591.01   | 591.02  |
| B10         | 668.14   | 668.02   | 667.02   | 667.73  |
| B12         | 544.88   | 545.74   | 543.80   | 544.80  |
| B16         | 556.58   | 555.89   | 555.98   | 556.14  |
Table 4
The percentage elongation of the steel rod samples.

|          | Sample 1 | Sample 2 | Sample 3 | Average |
|----------|----------|----------|----------|---------|
| EA       | 9.08     | 9.18     | 8.80     | 9.02    |
| IA       | 11.92    | 12.26    | 10.98    | 11.72   |
| SA       | 9.94     | 9.93     | 10.01    | 9.80    |
| OA       | 10.00    | 10.1     | 10.30    | 10.1    |
| AA       | 10.16    | 10.18    | 10.01    | 10.1    |
| ALA      | 9.87     | 9.48     | 10.34    | 9.89    |
| A12      | 30.96    | 31.67    | 31.64    | 31.42   |
| A16      | 29.22    | 28.11    | 26.52    | 27.95   |
| B10      | 26.08    | 28.07    | 27.17    | 27.11   |
| B12      | 32.11    | 30.65    | 31.88    | 31.54   |
| B16      | 29.68    | 32.08    | 29.51    | 30.42   |

Table 5
The hardness and carbon equivalent values (CEV) of the steel rod samples.

| Samples | CEV  | Hardness (HRC) |
|---------|------|----------------|
| EA      | 0.720| 21.19 ± 1.10   |
| IA      | 0.692| 20.22 ± 0.98   |
| SA      | 0.677| 19.63 ± 1.00   |
| OA      | 0.704| 20.45 ± 1.12   |
| AA      | 0.727| 21.23 ± 0.80   |
| ALA     | 0.698| 20.34 ± 0.85   |
| A12     | 0.500| 18.04 ± 1.20   |
| A16     | 0.575| 18.21 ± 1.11   |
| B10     | 0.650| 20.71 ± 1.22   |
| B12     | 0.444| 16.83 ± 0.88   |
| B16     | 0.572| 17.05 ± 1.44   |

2. Experimental design, materials, and methods

Steel rod samples of 12 mm diameter were collected from six different collapsed building sites in Lagos, Nigeria. These sites include a 2-storey building at Ewutu area (EA), 3-storey building under construction at Ilesanmi area (IA), 3-storey building at Ojo area (OA), a storey building at Agege area (AA), two- storey building Alagbado area (ALA) and a storey building at Sango area (SA). Five other samples of steel rod were obtained from two steel plants in Osun State, Nigeria. Steel rods of 12 and 16 mm diameters were collected from steel plant A and tagged as A12 and A16, respectively. Steel rods of 10, 12, and 16 mm were collected from steel plant B and tagged as B10, B12, and B16, respectively. Examples of these rods are shown in Fig. 1.

Optical emission spectrometer (Model RLMA, Serial No 871) was used for chemical composition analyses. Steel rod sample was sectioned into small sizes after which it was then ground using an industrial grinding machine with a 60-grit emery paper to relatively smooth surface. The polished sample was charged with argon gas so as to remove dirt or impurities. Argon gas was used because it is 99.9% inert gas (very pure and non-reactive). The sample was then placed in the optical emission with a monitor in order to determine the elemental compositions in mass percentage. Carbon equivalent value was estimated from some major elements using the relationship in Eq. (1). The tensile test for the samples was carried out using Instron Universal Tensile Testing Machine (Model Number 5569). The test specimens were cut to sizes as shown in Fig. 2 to grip properly to the jaw of the machine. During the test, the machine jaws were pulled apart automatically until the specimen necks eventually broken or fractured. As the load was slowly applied on the tensile specimen, load to
extension graphs were continually plotted as shown in Fig. 3. The ultimate tensile strength (UTS) was evaluated from Fig. 3 using Eq. (2). Similarly, the yield strength (YS) was calculated using Eq. (3). The two ends of the fractured samples were fitted together to obtain the final gage length as well as the diameter using venier calliper. The percentage elongation was determined using Eq. (4). Hardness of the samples was determined on a Brinell hardness tester (Model HBW, Serial no: VR-44, FOUNDRAX) with indenter with a diameter of 10 mm and load of 500 kg. The Brinnel hardness number was converted and reported as Rock well value (HRC).

\[
CEV = \%C + (\%Mn + \%Si)/6 + (\%Cr + \%Mo + \%V)/5 + (\%Cu + \%Ni)/15
\]

(1)

\[
UTS = \frac{M_L}{CSA}
\]

(2)

\[
YS = \frac{Y_L}{CSA}
\]

(3)

\[
\%\text{Elongation} = \frac{(L_f - L_0)}{L_0}
\]

(4)

where \%C is the percentage carbon content, \%Mn is percentage manganese content, \%Si is percentage silicon content, \%Cr is percentage chromium content, \%Mo is percentage molybdenum content, \%V is percentage vanadium content, \%Cu is percentage copper content, \%Ni is percentage nickel content, \(M_L\) is the maximum load (kN), \(Y_L\) is yield load (kN), CSA is cross-sectional area (mm\(^2\)), \(L_f\) is the final gauge length (mm) and \(L_0\) is the initial length (mm).
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Transparency document. Supporting information

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