USE OF LOCALLY AVAILABLE MATERIAL IN PAVEMENT SUB-BASE

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ABSTRACT: The depletion of resources is a major issue in the civil engineering from which the road construction cannot be excluded. Because of the extensive road construction, the aggregate demand is huge and causing lots of blasting, quarrying, crushing etc is carried out and are consuming energy as well, and the aggregate materials are depleting fast becoming short in supply. On the other hand, industrial by-products and locally available materials are causing environmental and dumping problems, however these can have a application in road constructions. In this study we undergo series of tests on two types of materials one is steel slag, and the other is locally available gravel in the sub-bases. The study concerns chemical composition, phase composition, toxic metals present in the slag and its leaching water, whereas its gradation and other physical properties are observed by undergoing tests. Partial amount conventional crushed aggregates are mixed in proportions to satisfy the desired grading mandatory by the Ministry of Road Transport and Highways. The percentage of the slag and gravel that can be used in sub-base layer is found to be 80% and 50% respectively. In case of gravel, cement was also used in required quantity to get the desired strength. It is observed that both the steel slag and hard gravel have excellent properties and can be used in the road base and sub- base applications.

KEYWORDS: Steel slag, XRD analysis, toxicity, modified proctor test, etc.

I. INTRODUCTION

The materials used in highway construction are also used in other construction activities (like homes, industrial complex, hydro dams, power plants etc.). Aggregates are composed of sand, crushed aggregates, gravels and natural materials that provide the necessary strength and durability. To meet the enormous demands of construction the above natural resources for aggregate are heavily brought down for the construction of roads houses etc, especially in urban markets.

The extraction of aggregates from hills via quarrying operations, crushing are not only responsible for the environmental degradation in the form of loss of forest lands, vibrations, dust, noise pollution hazards etc. but also consume a large amount of energy depleting the energy sources. Generation of a vast quantity of waste material from extraction industries like iron, steel, coal, etc. is causing shortage of dumping space and also creating severe environmental pollution. Solid waste generation from steel industries such as acid sludge from by-product plant, tar sludge, B.F. slag, steel slag, coke breeze, dolomite dust and steel scrap etc. are generated in vast quantities causing environmental degradation.

II. RELATED WORK

Steel slag is a residue obtained from the basic oxygen converter during steel-making operations. It can be partially used as a construction material for roads. Though it is an attractive construction material, before the application its long- lasting behaviour and the related environmental influences should be considered into account. BOF slag is generally composed of silicon, calcium, iron and some potential toxic elements or known as toxic elements, like chromium and vanadium. **[P. Chaurand., et al, 2006]**. A new type material comprised of steel slag, fly ash and phosphor-gypsum were used as a road base material in China. The chemical composition of the raw materials: steel slag, fly ash, and phosphor-gypsum were determined. The XRD patterns of two slag (steel slag) samples are illustrated in fig.2.2. **[Weiguo Shen., et al., 2009]**.

The work in this paper is divided in four stages. stage 1: gives a brief idea about the conventional and non- conventional materials used in the road construction and points out the objectives of the study using slag and gravel as non-conventional materials. Stage 2: gives an overall idea about the findings in different past studies on the use of either slag or gravel in road base or sub-base application. Stage 3: deals with the experimental methodology in which several test methods, analytical techniques as per different standards, specifications and studies are used to determine the characteristics of slag and also to find the physical properties of slag, gravel and conventional crushed aggregates. Stage 4: provides the results of all the tests and techniques followed in chapter 3 and checks their validation with reference to corresponding standards and specifications.

III. OBJECTIVE

The objectives of this work are:

♦ To determine the chemical composition, and note down the presence of hazardous materials in the slag and its drained leachate water.

♦ To determine the physical properties of slag and calculate its strength determining suitability for use in the sub- base.

♦ To determine the physical characteristics of locally available hard gravel and determine its suitability for use in the base or sub-base.

♦Assessment of the effects of stabilization in base or sub-base with natural aggregates and locally available gravel (hard gravel).

To determine Characteristics of slag: X-Ray

Fluorescence

X-Ray Diffraction

- Scanning Electron Microscopy (SEM) and Electron Dispersive X-Ray spectroscopy (EDX)
- Toxic Characteristic Leaching Procedure (TCLP) To

determine Physical Properties and Strength:

- Gradation
- Blending of aggregates
- Determination of Water Absorption and Specific Gravity
- Determination of Plasticity Index
- Aggregate Impact Test
- Combined Flakiness Index
- Modified Proctor Test
- Determination of California Bearing Ratio (CBR)
- Unconfined Compression Test
- Cube Specimen

IV. EXPERIMENTAL RESULTS

The compressive strength of cement stabilised cube specimens of 15 cm ×15 cm ×15 cm was determine. Specimens were prepared to the predetermined maximum dry density taking materials passing sieve of 37.5 mm compacted at the optimum moisture content. The compaction was done through a vibratory hammer fitted with three tampers with specified heights for compaction in three layers each is of 5 cm of the cube.

(a) (b) (c) (d) (e)

Fig. 1. Sequences involved in preparation and testing of cylinder specimens (a) Tamper used for compaction of cylindrical specimens, (b) Cylindrical mould of 102 mm diameter and 203 mm height used for compaction, (c) Removal of specimen from the mould after 24 hours, (d) Weighing of specimen after proper sealing, (e) Curing of specimens in the BOD incubator at a constant temperature 23.7C

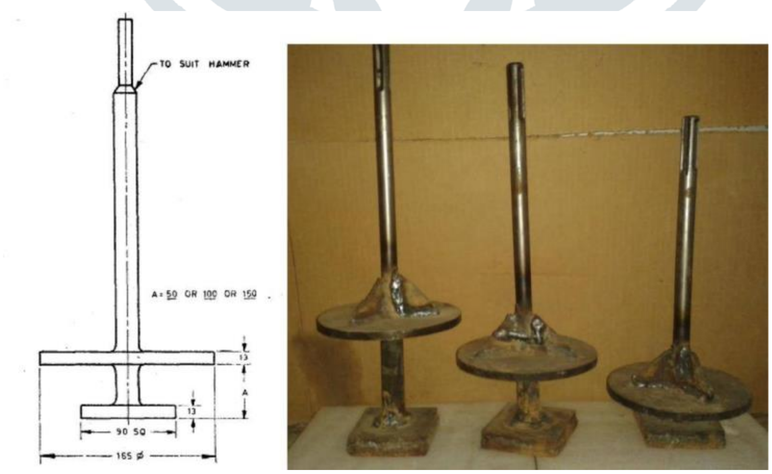

Fig. 2 Tampers for use with a vibrating hammer for Unconfined Compressive strength test

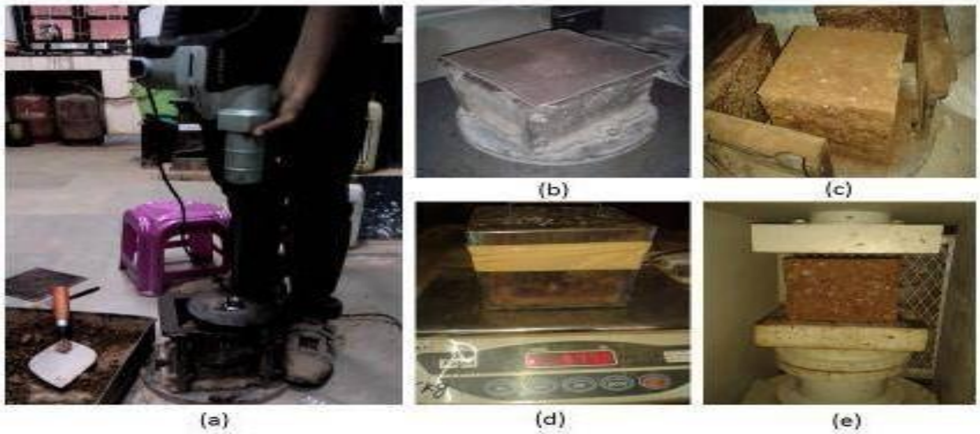

Fig. 3 Sequences involved in preparation and testing of UCS of cube specimens (a) Compaction of materials in a cube mould using a vibratory hammer, (b) cube mould covered with a metal plate (160 mm× 160 mm× 3 mm), (c) removal of specimen from the mould after 24 hours (d) weight measurement of cube specimen inside a properly sealed curing tin (160 mm x 160 mm x 155 mm), (e) Unconfined compression test of specimen (after 7 days) using a Compression testing machine

The unconfined compressive strength values of the combination of crushed aggregates and combination of gravel and crushed aggregate blends for use in different layers with varying cement content are presented below. The UCS values of cube specimens for use in the drainage layer of cement treated sub-base and the comparison of UCS values of cube specimens with the equivalent UCS values of cylinder specimens for cement treated base and filter layer of cement treated sub-base was also calculated and came out to be equal to that of conventional aggregate.

V. CONCLUSION

Characteristics of Slag

1 The slag sample used in this work contains about 30% by weight of both CaO, SiO2 and 20% by weight of FeO and some amount of Al2O3 and MgO, confirms the slag as steel slag.

2 The phases present in the slag are in carbonate, hydroxide or silicate form rather than oxide form making it suitable for construction purposes.

3 The heavy and toxic metals present in the slag and its leachate water are either zero or negligible. Hence, the potential for environmental hazards is very low.

4 The slag samples are well graded which require less amount of crushed (conventional) aggregates for blending to meet the desired grading for use in different layers of sub-base. For filter layer a maximum up to 76% slag and for drainage layer a maximum up to 80% slag can be used to satisfy the desired grading (GSB grading II and grading IV respectively as per the MoRTH specifications).

Physical properties:

1 The finer material content in the gravel used for this work is very high. Hence, the amount of gravel that can be used for base and sub-base is limited to 50% in the total aggregate blend.

2 The impact values of the slag, crushed aggregates and wet impact value of gravel are within the maximum limits for road base or sub-base applications.

3 The specific gravity of the slag aggregates is much higher than that of the crushed aggregates. Hence, the MDD and CBR values of the slag and aggregate blends are very high.

4 The specific gravity of gravel is comparatively more than that of the crushed aggregates. Hence, the MDD values are also higher in the gravel aggregate blend.

5 Cement is used as a binder for stabilization of gravel because of its high plasticity (PI= 20). The UCS values of the combination of gravel and crushed aggregates specimens satisfy the desired lower limits for use in the cement treated base or sub-base layers.

6 The UCS value of cement treated gravel-crushed aggregates blend is more as compared to that of crushed aggregates blend for particular cement content.

REFERENCES

[1] Aiban, S. A. "Utilization of steel slag aggregate for road bases." *Journal of Testing and Evaluation* 34, no. 1 (2006): 65.

[2] Behiry, A. E. A. E. M. "Evaluation of steel slag and crushed limestone mixtures as subbase material in the flexible pavement." *Ain shams Engineering Journal* 4.1 (2013): 43-53.

[3] Chaurand, P., Rose, J., Briois, V., Olivi, L., Hazemann, J. L., Proux, O., Domas, J., & Bottero, J. Y. "Environmental impacts of steel slag reused in road construction: A crystallographic and molecular (XANES) approach." *Journal of Hazardous Materials* 139.3 (2007): 537-542.

[4] Emery, J. J., "Slag Utilization in Pavement Construction", *Extending Aggregate Resources, ASTM STP 774*, 1982, pp.95-118.

[5] Indoria, R. P. "Alternative materials for Road Construction", *Indian Highways*, May 2011

[6] IS: 2386 (Part-I), "Methods of Test for Aggregates for Concrete: Particle Size and Shape", *Bureau of Indian Standards, New Delhi*, 1963

[7] IS: 2386 (Part-III), "Methods of Test for Aggregates for Concrete: Specific Gravity, Density, Voids, Absorption, Bulking", *Bureau of Indian Standards, New Delhi*, 1963

[8] IS: 2386 (Part-IV), "Methods of Test for Aggregates for Concrete: Mechanical Properties"

[9] IS: 2720 (Part 2), "Method of Test for Soils: Determination of Water Content", *Bureau of Indian Standards, New Delhi*, 1973.

[10] IS: 2720 (Part 5), "Method of Test for Soils: Determination of Liquid and Plastic Limit",*Bureau of Indian Standards, New Delhi*, 1985