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Use of Waste Materials in Construction of Road Pavements

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ABSTRACT: The construction industry has gained very fast growth in recent eras due to the increase in the population, increase in the IT sector and increase in the industrialization and also introduction of new infrastructure projects resulted in the increase of construction industry severely. Due to which the demand for construction materials is huge for the construction activities which results in the generation of huge amount of construction waste. Construction material wastage resulted in the huge financial setbacks to builders, contractors, regional authorities and also to the country. The objective of the paper is to study the feasibility of the application of Construction Demolition Waste (CDW) for improving the performance of sub grade and sub base layers in the road design. On this mixture, standard tests will be conducted like Aggregate Impact Value Test, Crushing Value Test, Specific Gravity Test, Water Absorption Test, and Loss Angeles Abrasion Test. The results will be analyzed and discussed for the application of CDW for improving the performance of sub grade and sub base layers in the highways. In Construction Demolition Waste (CDW) we have mainly focused on the properties of aggregates and bricks which are major waste in CWD, and how to use this in sub grade layer and sub base layer to achieve the strength and economy while considering the environmental factors. The results will be analyzed and discussed for the application of CDW for improving the performance of sub grade and sub base layers in the roadways.

KEYWORDS: construction demolition waste, standard tests, sub-grade, sub-base layers, mixture, water absorption

I. INTRODUCTION

It is believed that the oldest mode of travel was on the footpaths later on, with the development of bullock carts and other simple animal drawn vehicles, roads were also developed. These early roads were constructed as Kutcha roads, consisting of ordinary earth. The Kutcha roads were soon deteriorated under heavy bullock cart traffic thus metalled roads came into existence. The first indication of these roads in pre-historic period has been revealed by the excavation at Mohenjo-Daro and Harappa. It is believed that these towns were constructed 3500 years B.C. Earth and paved street pavements have been found in both of these unearthed towns.

These history of India does not reveal much about the different construction materials used during different periods. However, the remains of the road in Rajgir (Patna dist), constructed in 6th century B.C. i.e. During Aryan period and some archeological records show that the materials commonly used at that time for road construction were stones the undressed form.

This material was used only for metaling the major roads where as all other roads were constructed as ordinary roads. In towns, the road pavements used to be of undressed stone slabs. With the developments of fast moving tyred vehicles WBM road pavements could not last longer as they create dust nuisance during dry weather and become muddy during monsoon. In order to minimize dust nuisance, a thin coat of bituminous materials was tried with varying degrees of success.

In India nearly 50% of Construction & Demolition waste is being re-used and recycled, while the remainder is mostly land filled. In India its common practice for large Construction and Demolition (C&D) projects to pile waste in the road, resulting in traffic congestion. C&D waste from individual households finds its way into nearby municipal bins and waste storage depots making the municipal waste heavy, and degrading its quality for treatments such as

composting or energy recovery. The Indian construction industry is highly labor intensive and has accounted for approximately 50% of the country's capital outlay in successive Five-Year Plans, and projected investment continues to show a growing trend. Out of 48 million tons of solid waste generated in India, C&D waste makes up 25% annually.

II. MATERIALS

A. Waste Aggregate

Recycled aggregates are the aggregates obtained from construction and demolition waste (CDW), from residential, commercial, industrial structures or from pavements as shown in fig. These aggregates can be re-used in all the construction activities with some % of volume of construction, in order to have the same mechanical properties of hardened concrete, without disposing these waste materials into the environment. It has been felt that recycling would be the most promising waste management process for the disposal of materials. This will also help in less dependence of aggregates required in making rigid or flexible pavements over a long period. Due to issues related to sustainability and limited natural resources, it is clear that the use of recycled, like crushed concrete and asphalt, will be very useful in cost of saving also.



fig. a. Waste Aggregate of Road Pavement



fig.b. Waste Aggregate of demolished building

B. Cement:

The manufacturing of Cement was conducted by heating limestone (calcium carbonate) with small quantities of other materials (such as clay). A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together cement will act as a bonding material.

III. METHODOLOGY

A processed waste material, which is proposed to be used for road construction, is to be evaluated for its environment, health and safety hazards, physical, chemical and engineering properties, cost effectiveness, field performance etc. If environment, health and safety valuation results are negative, the candidate material is rejected as a road construction material and is recommended for safe disposal. If the material satisfies the environmental, health and safety criteria, then it is further evaluated for its physical, chemical and engineering properties. If the chemical and physical properties of the candidate material are similar to that of traditional construction materials, then existing testing protocols may be used for evaluation of its engineering properties.

Otherwise, new test procedures are to be developed. For standard materials, the testing procedures and acceptance specifications are prescribed by highway agencies or local public works departments. Further, cost evaluation needs to be performed to check the economic possibility of using the candidate material as replacement of traditional pavement material. Sometimes life cycle cost evaluation is conducted to study in detail the overall impact of the new material on the total cost of the road project (throughout its service period, including all maintenance activities). Finally, it is important to conduct field trial with the new material to gather information on the short-term and the long-term performance of the road. Performance studies also help to develop acceptance specifications for new road materials.

EXPERIMENTAL STUDY AND LABORATORY TESTS

We have collected the demolition construction material of slab, beam and column from RITESH RUNAL DEVELOPER, SATARA as per requirement and grading of aggregates given in IS: 383-1970. We have segregated the aggregate according to requirement and we have used the aggregate which retains on 10mm sieve and passes from 12.5mm sieve. Fine aggregate comprises of stone dust with fraction passing 4.75 mm and retained on 0.075mm IS sieve. We have performed the number of tests on aggregate to check their properties and to compare its properties with normal aggregate. After comparison we have concluded the result. Number of tests performed is listed below: -

1. AGGREGATE IMPACT VALUE

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used for determining aggregate impact value of coarse aggregates is

Impact testing machine conforming to IS: 2386 (Part IV)- 1963, IS Sieves of sizes – 12.5mm, 10mm and 2.36mm, A cylindrical metal measure of 75mm dia. and 50mm depth, A tamping rod of 10mm circular cross section and 230mm length, rounded at one end and Oven.



Fig. 1 Impact Value Test Apparatus

2. CRUSHING VALUE TEST

The 'aggregate crushing value test' gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. Aggregate crushing value is defined as the percentage by weight of the crushed (or finer) material obtained when the test aggregates are subjected to a specified load under standardized conditions, and the strength of the aggregate used in road construction is expressed by numerical index.



Fig.2.1 Aggregate crushing value test apparatus



Fig. 2.2 Aggregate Sample

3. SPECIFIC GRAVITY TEST.

Specific gravity test of aggregates is done to measure the strength or quality of the material while water absorption test determines the water holding capacity of the coarse and fine aggregates. The main objective of these test is to,

1. To measure the strength or quality of the material.
2. To determine the water absorption of aggregates.

4. WATER ABSORPTION TEST

This test helps to determine the water absorption of coarse aggregates as per IS: 2386 (Part III) – 1963. For this test a sample not less than 2000g should be used. The apparatus used for this test are :-

Wire basket – perforated, electroplated or plastic coated with wire hangers for suspending it from the balance, Water-tight container for suspending the basket, Shallow tray of minimum 650 sq.cm area, Air-tight container of a capacity similar to the basket and Oven.

Recommended Values of Specific Gravity and Water Absorption for Aggregates

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68.

Water absorption shall not be more than 0.6 per unit by weight

5. MARSHAL STABILITY TEST

In conducting the stability test, the specimen is immersed in a bath of water at a temperature of $60\% \pm 1^\circ\text{C}$ for a period of 30 minutes. It is then placed in the marshal stability testing machine and loaded at a constant rate of deformation of 5mm per minute until the failure. The total maximum load in kN is taken as marshal stability. The stability value so obtained is corrected for volume. The total amount of deformation in units of 0.25mm that occurs at maximum load is recorded as flow value. The total time between removing the specimen from the bath and completion of the test should not exceed 30 seconds.



Fig.5.1 Marshal Stability Test Specimen



fig.5.2 Marshal Stability Testing

6. LOS ANGELES ABRASION TEST

Abrasion testing determines the relative quality, toughness, and durability of mineral aggregates subjected to impact and abrasion. Values derived from both the Micro Deval and the L.A. Abrasion tests offer information about the performance of aggregate in use. This testing offers insight into how asphalt and concrete aggregates will stand up to wear and tear over time. It's also a good indicator of changing properties in an aggregate source as part of quality control or quality assurance program.



Fig.6.1 Los Angeles Abrasion Test Apparatus

IV. RESULT

Result of aggregates test:

Available results point out that there is plenty scope for utilization of waste materials for road construction. However, one needs to proceed cautiously, because of possible environmental, health and safety concerns associated with the India-age of some of the waste materials.

This research is needed before any specific waste material is finally approved as an alternative road construction material. It is expected that availability of suitable technology, appropriate legislation and awareness among all stake holders would widen the possibilities of using some of the waste materials for sustainable road construction.

Sr. No.	Name of Test	CWD	Conventional Aggregate	Range	Remark
1	Aggregate Impact Test	11.65%	5.8%	<10% (exceptionally strong); 10-20% (strong)	Hence the values are in optimal range, so we can use it in all the layers except top wearing surface layer of road pavement.
2	Aggregate crushing value test	12.60%	10.86%	<45% (Wearing course); <30% (Concrete pavement)	
3	Specific gravity value test	2.50	2.53	2.5-3.0	
4	Water absorption value test	1.20%	1.69%	0.1%-2.0%	
5	Los Angeles abrasion test	27.85%	10.89%	<40%	

- The Impact Value of demolition aggregates is 11.65 %. This indicates that the aggregates are strong.
- The Crushing Value of demolition aggregates is 12.60% which is less than 30 %. So the aggregates are suitable for the surface course.
- The Specific Gravity of demolition aggregates is within the specified range. So, the aggregates are suitable for the road surface.
- The Water Absorption of demolition aggregates is greater than 1.20 %. So, the aggregates are suitable for the study.
- The Loss Angeles Abrasion Value of demolition aggregate is 27.85%. So, the aggregate is suitable for road pavement design.

Thus, all the tests on demolition aggregates were successful and the aggregates are best suited for the design of road pavement.

Result of marshal stability test:

Sr. no.	Name of test	CDW	Conventional aggregate	Range	Remark
1	FLOW VALUE (mm)	2.90	3.27	2-4	Hence the values are in optimum range, so we can use in DBM course.
2	CORRECTED MARSHAL STABILITY VALUE (KN)	9.06	10.11	8.2 minimum	

- The Flow Value of demolition aggregates is 2.90 mm. So the aggregates are suitable for the DBM course in pavement.
- The Corrected Marshal Stability Value of demolition aggregate is 9.06KN. So the aggregate are suitable for road pavement design as a DBM course.

V. CONCLUSION

Tests were conducted to study the properties of the construction demolition wastes in pavement design as a DBM course. The results of normal aggregate and construction demolition aggregate compared to study the effect on the properties of road pavement.

- Marshall Stability of conventional aggregate was found to be 10.11KN.
- Average Flow of the conventional aggregate was found to be 3.27mm.
- Marshall Stability of CDW aggregate was found to be 9.06 KN.
- Average Flow of CDW aggregate was found to be 2.90mm.

Thus, the Marshall Stability of construction demolition wastes was found 10.11 KN which satisfies the requirement criteria for DBM course as per given in MORTH specification.

The above result shows that CDW aggregate can be used in pavement design as a DBM course which minimize the requirement of conventional aggregate and can be helpful in controlling the environmental pollution.

To use the CDW aggregate in pavement design, we need to segregate it from its various constituents that causes rampant growth of construction sector as to establish a new crusher and segregation plant.

With rapid increase in industrialization and infrastructure development which leads to the generation of CDW waste and by disposing it, in a river or use it as a land fill it causes environmental pollution. So, to minimize it we can recycle and reuse the CDW waste as aggregate in road pavement design which will control the land pollution.

To use conventional aggregate, we need crushing and segregation plant so in the same manner, to use CDW aggregate we also required recycling plant. The cost difference in both the process seems to be same and other process of road construction is same for both the aggregate.

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