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Utilization of Construction and Demolition Waste in Flexible Pavements

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Abstract: The world's population has increased in recent decades, so as a result of this, the construction sector is also growing very rapidly. The construction sector is producing lots of construction and demolition waste. This C&D waste is very harmful to our environment and also to the economies of developing countries. There are very few disposals or treatment plants for C&D waste. As we know, disposal sites need a large space. As for construction, the demand for natural resources has increased, and it's becoming a challenge to save these natural resources for future generations. So, this study is based on the use of C&D waste on flexible pavements. The purpose is to use the C&D waste as an aggregate in road construction instead of natural aggregate. This will help us save natural aggregates.

Keywords: aggregate testing, construction and demolition waste, mixture, recycling.

1. Introduction:

1.1 General

The development of a country highly depends on the road infrastructure it possesses. With a total length of 5.6 million km, India has one of the world's greatest road networks (km). In recent years, there is a tremendous increase in road transportation with the improvement in connectivity between cities, towns and villages in India. As of April 2018, there were 1,529 Public Private Partnership (PPP) projects in India, of which 740 were related to roads which accounts to 51.60 % of total share. The construction of highways reached 122,432 km during 2017-18 which was constructed at an average of 28 km per day (MoRTH, 2016). The increasing demand for construction of roads has led to the depletion of natural resources used for road construction. therefore ,it is the need of the hour to find a substitute for the natural materials available.([1] Abdollahnejad, 2019)) In the past few years research has been focused on finding new alternatives.

The use of recycled asphalt pavement (RAP) has gained popularity over the years and is now being adopted throughout the world ([2] ACI Committee 544. (2009). Report on Fiber Reinforced Concrete, 2009)

However, till date most of the C&D waste in India is disposed of as landfills which in turn burdens the environment and threatens the sustainable development in the country.The total quantum of waste from the development trade is calculated to be twelve to fifteen million tons each year. Of that, seven to eight million tons could be concrete and brick waste.([3] Ahmari, 2012). Recycling and subsequent reuse of C&D materials will decrease the demand for natural aggregates as well as reduce the problem of disposal of C&D waste. The key components identified for construction and demolition waste are concrete, soil, brick, wood, asphalt, and metal. Bricks, stone, concrete, and soil make up more than 60% of all waste.(CPCB, 2016)([4] Ahmed Shaikh, 2016) Recycling and subsequent reuse of C&D materials will decrease the demand for virgin natural aggregates as well as reduce the problem of disposal of C&D waste. At the North Delhi Municipal Corporation in Burari, IL & FS Environment built India's first large-scale C & D waste recycling plant..([5] ahmed shaikh, 2016). By recycling aggregate for construction purposes, the Burari facility will help Delhi reduce the pressure of 5,000 tonnes of construction and demolition waste generated daily. The plant's C&D waste is used to make ready-mix concrete, kerb stones, tiles, concrete bricks, and other building products. The possibility of employing C&D waste in road construction, on the other hand, has yet to be investigated. ([6] Al-bayati H.K.A., 2016)

The use of aggregates in road construction accounts for 90-95% of all materials required for road construction. As natural resources needed in road construction become limited, the cost of hauling good quality stone aggregates rises.The environmental costs of quarrying are also substantial. As a result, there is a strong desire to discover a replacement for natural aggregates. ([7] Bagampadde, 2005)

Research on how to successfully employ recovered construction waste in civil engineering applications has been done around the world in recent years. C&D waste is referred to as recycled concrete aggregate when it is recycled and reused as aggregate in new construction (RCA).Various studies on RCA have mainly analyzed the properties of C&D waste and demonstrated its

feasibility as road base or sub base. Hence,It has been discovered that recycling and reusing C&D waste in road construction has a high potential.

1.2 Construction and Demolition Waste

Concrete, tile, brick, metal, glass, and other materials are examples of C&D waste.[13]. A part of this waste is disposed of in the municipal waste.This waste contains large materials like bricks, tiles, concrete blocks,wooden items,metal items.([8] Baker, 2018).The C&D waste is mainly generated from renovation, demolition and from new construction.Renovation and demolition are the two major reasons behind construction and demolition waste generation.

According to reports indian construction sector generates 11-12 million tonnes of construction waste per year.Some reports says in India there is chance of shortage of natural aggregates due to this rapid construction.

Concrete and masonry waste, which account for more than half of construction and demolition waste, is not recycled in Asian countries. But in some developed countries this type of waste is recycled with proper guidance. ([9] Bassani, 2019)

1.3 Construction & Demolition Waste in Road Construction

Despite the pandemic-related blockages and restrictions on movement in most parts of the country, highway construction from April to May of this fiscal year increased by 74% compared to the previous year, to 1,470 km, or 24.1. It was km/day.([10] Behera, 2014)

Asphalt and concrete pavement require a large amount of aggregate. Natural aggregates are the most commonly used aggregates in road construction . This is the main cause of the shortage of these aggregates, and as a result of rapid infrastructure development, buildings are destroyed and solid waste is generated. Therefore, disposal of non-biodegradable construction and demolition waste is a challenge. For both economic and environmental reasons, the limited space available for concrete disposal was a serious environmental problem.

Recycled concrete aggregate (RCA) is made from dismantled old concrete structures [12]. Recycled aggregate recovered from destroyed building materials can be used to build roads and highways.

2. Experimental Study

The construction and demolition waste from C&D plant, Sec13, Chandigarh, and aggregates from Rana Trading Company, SAS Nagar, Chandigarh, are collected and crushed according to the size of gradation required in the experimental investigation. IS: 383-1970 is used to grade the work. We separated the aggregate according to the requirements and used the aggregate that passes through a 12.5mm screen and retained on 10 mm sieve. Tiles, bricks, and concrete are among the materials employed. We conducted a number of tests on aggregates like aggregate impact test, crushing value test, water absorption test and abrasion test to determine their qualities and compare them to natural aggregates.

2.1 Material Used

a) C&D waste aggregates (RCA) were collected from the C&D facility in Chandigarh, Sec 13.

b) Natural Aggregates are procured from Rana Trading Company,Chandigarh.

c)Bitumen is collected from Classic Bitumen , Sec 30C, Chandigarh.

2.2 Aggregate/CDW Test

a) Gradation Analysis [IS: 383(1970)]

b) Aggregate impact value test for aggregates [IS:2386Part –4(1963)]

c) Crushing value test for aggregates [IS:2386Part –4(1963)]

d) Water absorption test for aggregates[IS:2386 Part–3(1963)]

e) Abrasion test[IS:2386Part–4(1963)]

2.3 Bitumen

VG 30 grade Bitumen is used in this study and some test are conducted on bitumen which are given as below

a) Penetration Test For Bitumen[IS:1203-1978]

b) Softening Point Test For Bitumen [IS:1205-1978]

c) Ductility Test For Bitumen [IS:1208-1978]

d) Specific Gravity Test For Bitumen [IS:1202-1978]

2.4 Marshall Mix Design

2.5 Indirect Tensile Strength Test

Fig 1 Marshall Stability Testing Machine

Fig 2 Crushing Value Test

Fig 3 Aggregate Impact Test

Fig 4 Abrasion Test

Fig 5 C&D Plant Chandigarh

3.Result and Discussion

3.1 Result of Aggregate Test

The available data indicates that there is plenty of scope for waste materials to be used in road construction. However, because to possible environmental, health, and safety risks linked with the India-age of some waste products, caution is advised.

Before any specific waste material can be certified as an alternate road construction resource, more investigation is required. It is envisaged that the availability of adequate technology, acceptable regulation, and increased knowledge among all stakeholders will increase the possibility of utilizing some waste materials for long-term road development.

Hence the values of aggregate tests are in optimum range,so we can use it in all the layers expect top wearing surface layer of road pavement

Table 3.1 Aggregate Test Results

Sr. No.	Test	CWD	Natural Aggregates
1	Aggregate Impact Test	11.33%	7.01%
2	Crushing Value Test	20.76%	16.35%
3	Water Absorption Test	1.24%	0.51%
4	Los Angeles Abrasion Test	19.23%	15.85%

3.2 Bitumen Test Results (Viscosity Grade 30)

Bitumen Test	Value
Penetration Test For Bitumen	66.43mm
Softening Point Test For Bitumen	46.34C
Ductility Test For Bitumen	51.43mm
Specific Gravity Test	1.121

Table 3.2 Bitumen Test Results

3.3 Marshall Mix Design

Marshall Stability is high for the C&D mix .Bricks and tiles in rubble require more bitumen to be gently coated, so as the proportion of rubble increases, the flow value decreases. Since the specific density of debris is lower than that of normal aggregate, the specific gravity is also small.We get the highest value of Marshall Stability at 30% which is 12.97. By Performing Marshall Mix Design We gets the flow value , percentage air voids value and VFB value which is shown in the table below.The C&D waste percentage is taken as 20,25 and 30 . The bitumen percentage is steady at 5.5% of the C&D samples.

Table 3.3 Marshall Mix Design Test Results

Trial No.	**CDW (%)**	**Stability Value (KN)**	**Flow Value (mm)**	**Bulk Specific Gravity (Gm)**	**Percent Air Voids%**	**Volume of bitumen %**	**Void filled with bitumen %**
1	**0**	11.15	3.14	2.32	3.23	12.465	79.145
2	**0**	11.27	3.24	2.34	3.18	12.357	79.20
3	**0**	11.24	3.27	2.362	3.162	12.553	79.17
Avg.		11.19	3.21	2.353	3.190	12.458	79.171
1	**20**	12.25	3.16	2.27	4.231	11.435	72.145
2	**20**	12.27	3.18	2.288	4.345	11.344	72.243
3	**20**	12.33	3.12	2.32	4.384	11.267	72.434
Avg.		12.28	3.153	2.319	4.32	11.348	72.274
1	**25**	12.4	2.85	2.257	5.35	11.167	66.876
2	**25**	12.56	2.93	2.263	5.40	11.132	66.765
3	**25**	12.87	2.87	2.287	5.43	11.154	66.944
Avg.		12.643	2.883	2.271	5.393	11.151	66.861
1	**30**	12.70	2.67	2.231	5.765	10.878	65.986
2	**30**	12.56	2.87	2.234	5.786	10.675	65.876
3	**30**	12.97	2.65	2.263	5.878	10.576	65.933
Avg.		12.743	2.73	2.252	5.809	10.709	65.931

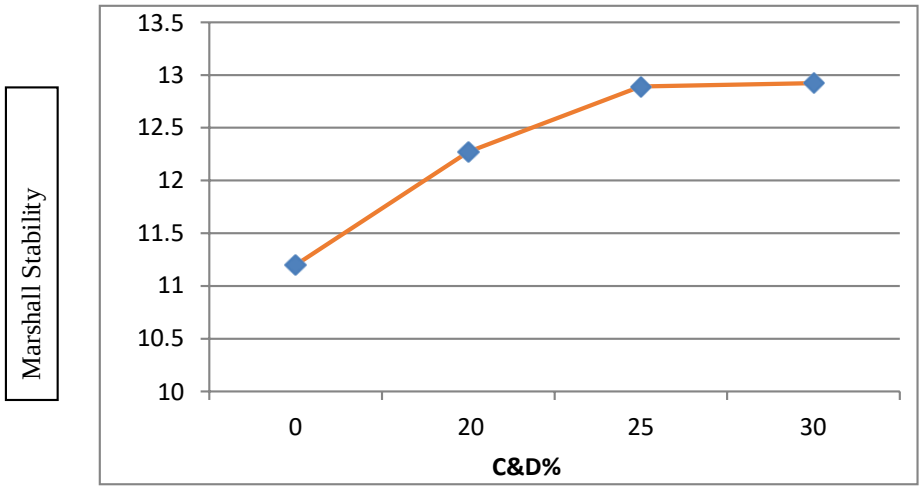

Fig 6 Marshall Stability vs CDW

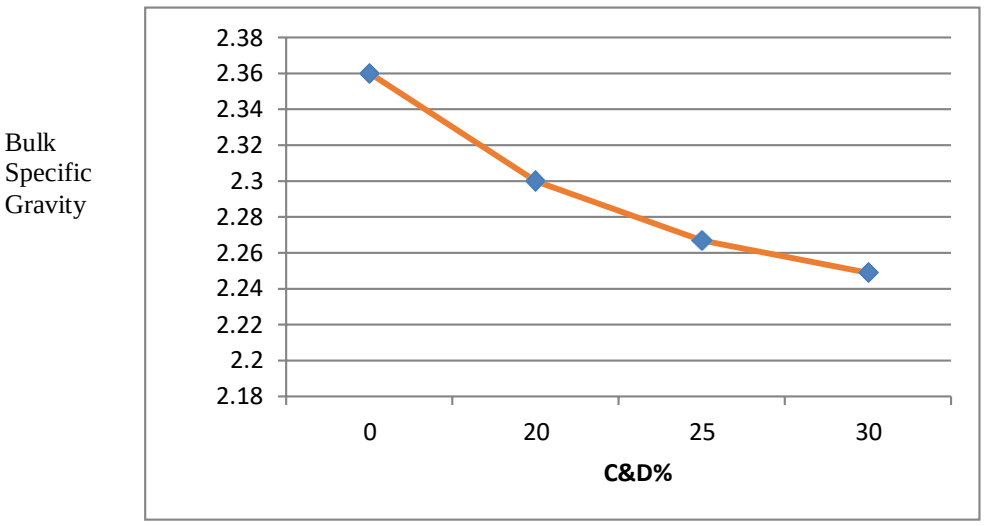

Fig 7 Bulk Specific Gravity Gravity

3.4 Indirect Tensile Strength (ITS) Test

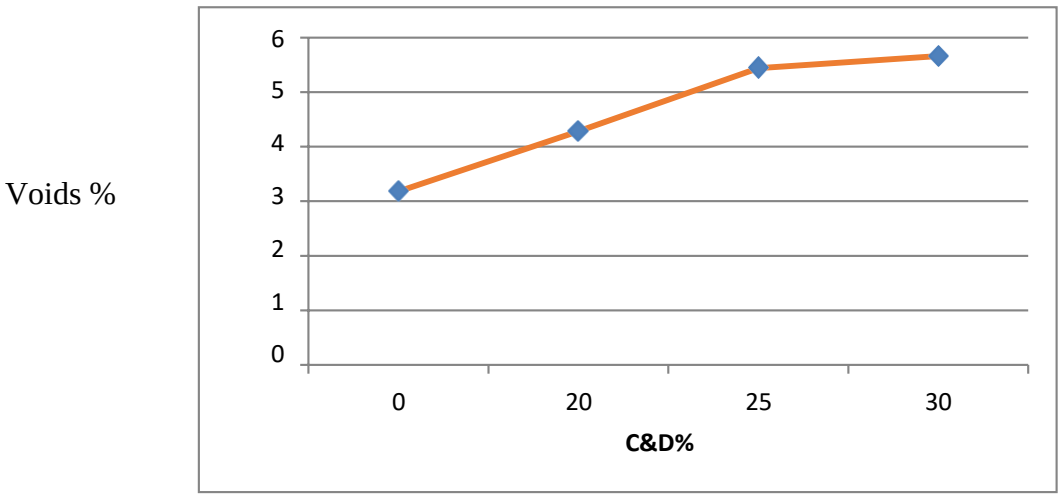

Fig 8 Volume of Voids

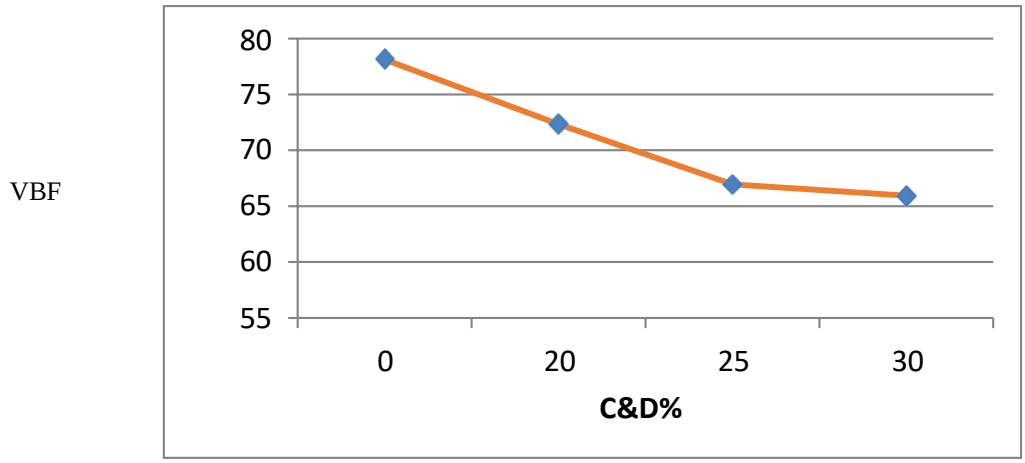

Fig 9 Volume filled with C&D

Table 3.4 Indirect Tensile Strength Results

CDW (%)	Unconditioned (N/mm^2)	Conditioned (N/mm^2)	Indirect Tensile Strength Ratio N/mm^2
0	0.540	0.470	0.746
20	0.612	0.478	0.743
25	0.617	0.482	0.717
30	0.701	0.513	0.719

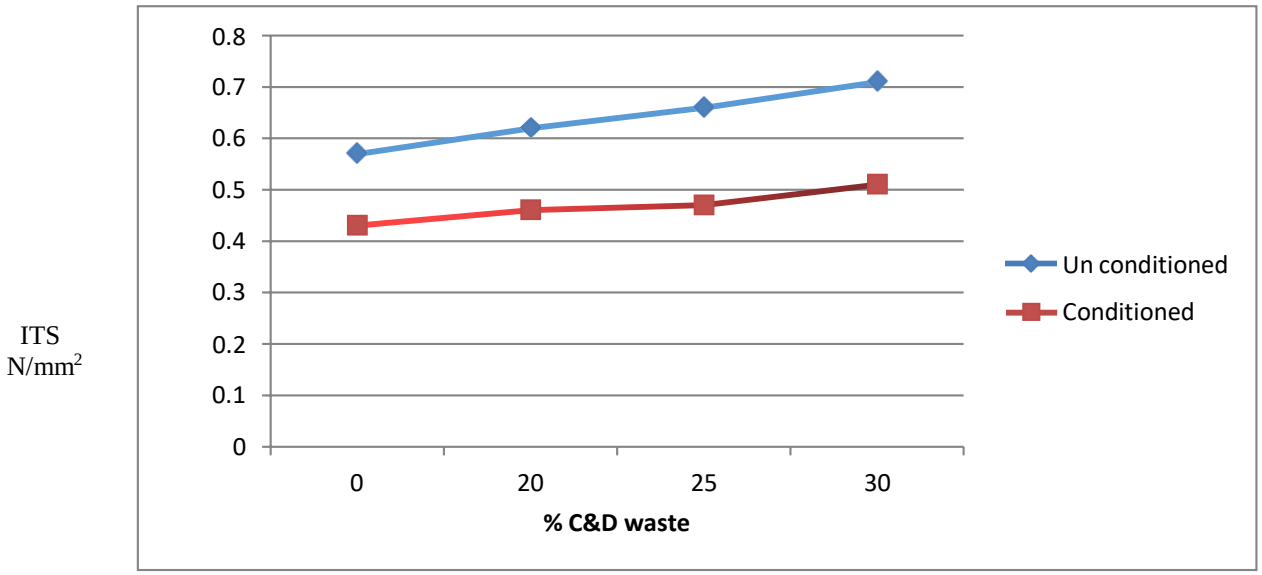

Fig 10 Indirect Tensile Strength Test

The Construction & demolition modified mix has a higher ITS as compare to normal mix .So, as by results we can say that the construction and demolition mix is having more chance of getting wet.

4.Conclusion

1) The aggregated test performed is within the limits of IRC. Test results show that the marshall stability of the modified structure and demolition mixture is greater than that of the normal mixture. Bricks and tiles are less dense than traditional combinations, further reducing their relative bulk density.

2) The results of ITS (Indirect tensile strength) test results shows some positive outcome and are showing some improvement. At 0% C&D waste, the indirect tensile strength is 0.540 N/mm2, while at 30% replacement, it is 0.701 N/mm2. However, there's a decrease in its quantitative relation which implies a risk of wetness.

3) We can say that we can use construction and demolition waste as an aggregate instead of natural aggregates because we got positive results after analyzing the samples, which will help us reduce construction and demolition waste.

4) With speedy increase in manufacture and infrastructure development that ends up in the generation of CDW waste and by disposing it, during a watercourse or use it as a land fill it causes environmental pollution. So, to minimize it we will recycle and utilize the CDW waste as combination in road pavement style which is able to management the land pollution.

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