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Design of hydraulic bound layer for ballastless track

Nandhini M [1], Jaghan S [2]
[1]Research Scholar, Department of Structural Engineering, Chennai, India
[2]Assistant Professor, Department of Civil Engineering, Jeppiaar Engineering College, Chennai, India
***Corresponding author E.Mail: jaghan22@gmail.com**

ABSTRACT

Traditionally, railway tracks are ballasted. However, efficient and safe solutions that do not use ballasts have been developed in the past 40 years, called ballastless tracks, fixed tracks, slab tracks or simply non-ballasted track. The main view of the paper is to design a hydraulic bound layer for ballastless railway track and also to compare ballasted track and ballastless track. This emphasizes the advantage of using hydraulic bound layer and adopting ballastless track. Already this soil stabilization method is used in roadways and it has been proved to be efficient. It is an effort taken to see the efficiency in using it in railway ballastless track. The railway track layer is prepared by using stone aggregates of size 40mm to 60mm, sand, fly ash (pond ash) and cement of 53 grades Ordinary Portland Cement (OPC). The materials used were tested for its physical and chemical properties. The compressive strength of concrete cubes was found. Plate load test was also done for testing soil settlement. The test and analyzed results show that this is an excellent method to be used in railway ballastless track superior to conventional concrete.

Keywords: Soil stabilization, Hydraulic bound layer HBL, Hydraulic binder, flyash, compressive strength.

1. INTRODUCTION

Soil stabilization: The process of combining soil, cement and water to produce a hard and durable paving stratum that is used for the foundation or base of road, railways and airport pavement is called soil stabilization. It is the permanent physical and alteration of soils to improve their physical properties.

Hydraulic bound layer (HBL): Hydraulic bound layer method is a soil stabilization method where a base layer is prepared between the ground surface and ballastless track which withstand the load applied on the track. HBL is a family of cement bounded layer where this method use binders made from following: cement, lime, gypsum, granulated blast-furnace slag, air-cooled steel slag, or coal fly ash. These binders are known as hydraulic binders since they set and harden in the presence of water.

Advantages of HBL:

Lower cost: Hydraulic bound mixtures made from in-situ materials or borrow-material taken from elsewhere on the site or nearby, are usually cheaper than the conventional approach

Fast construction: Modern construction methods make hydraulically bound mixtures quick and easy thereby reducing contract duration.

Sustainable construction: Since hydraulically bound mixtures can be made from site arising, recycled material or artificial materials, primary aggregate extraction is avoided.

Improved performance: Depending on the aggregate being treated, the properties of hydraulically bound mixtures can be superior to those of unbound granular materials.

Proven long term performance: Hydraulically bound mixtures in its various forms have been used in road, airfield, port and other pavement construction for over 50 years.

Ballastless track: Paved concrete tracks have the rail fastened directly to a concrete slab, about half a meter thick, without ties. The level of investment required is relatively high, but total life cycle costs will become increasingly important. It is used for its high speed and freight traffic, factors such as extended service life, low maintenance, availability and capacity for increased speeds and axle loads will gain in importance.

Material and its properties:

Soil stratum: At Koyembedu, Chennai, a rotary with mud circulation boring method is used to bore the ground. Bore hole is terminated at 45.3m. The soil sample is sieved mechanically by shaker apparatus. The description of soil is as follows,

- At a depth of 6m from ground level, the medium dense brownish silty sand is found.
- Soft dark grayish silty clay is found from 6m to 8m depth.
- At about 1m from the above stratum very loose blackish silty sand is found.
- From depth 9m to 12m soft dark grayish silty clay stratum is found.
- Brownish and firm brownish grey silty clay is found upto 13.5m
- Medium dense grayish silty clayey sand is found at the depth of 13.5m to 15m
- Stiff to very stiff brownish silty clay is found after 19.5m

Atterberg limit: This test is done to determine the plastic and the elastic limit of soil. This test is carried out as per IS: 2720, part 5, 1985.

Proctor Compaction test: The proctor compaction test is done as per IS2720 Part 7. The purpose of standard proctor compaction test is to determine the optimum water content and maximum dry density that can be achieved with a certain compaction effort.

Table.1.Test on soil

Atterberg Limit	Plastic limit	22%
	Liquid limit	46.15%
Proctor Compaction test	Dry density	2.11 gm/cc
	Moisture content	8.05%

Aggregates: The coarse aggregates used are passed through 12.5mm IS sieve and retained on 10mm IS sieve.

Aggregate crushing value: To achieve high quality of pavement aggregate possessing low aggregate crushing value is preferred.

Aggregate impact value: The resistance of the fracture under repeated impacts may be called as impact test for stone aggregates.

Table.2.Test on coarse aggregates

Aggregate Test	Values
Crushing value	21.78%
Impact value	19.4%

Cement: Ordinary Portland cement of 53 grades are used in this project.

Table.3.Properties of cement

Properties	Values	
Setting time	Initial time	30 min
	Final time	600 min
Soundness	10mm	
Specific gravity	3.15	

Flyash: Flyash is collected from Ennore Thermal Power plant, Chennai. It is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases.

Table 4(a) Properties of flyash

Chemical Properties	Values
SiO_2	56.77
Fe_2O_3	2.82
K_2O	1.96
TiO_2	2.77
Al_2O_3	31.83
MgO	2.39

Table 4(b) Properties of flyash

Properties	Values
Spcific gravity	2.2
Specific surface area	1.24 sq.m/g
Moisture content	0.2%
Weight density	1.75 gm/cc
Turbidity	459 NTU
pH	7.3

2. EXPERIMENTAL WORK

The testing sample is done as;

1. Conventional concrete as per mix design – Sample A
2. 10% replacement of cement weight with flyash – Sample B
3. 20% replacement of cement weight with flyash – Sample C

The concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing.

Fig. 1. Compressive strength of concrete

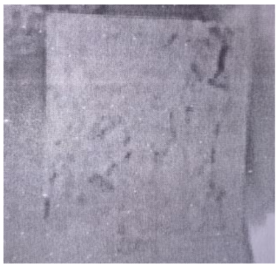

Fig. 2. Compressed con

The size of the cube mould is 15x15x15 cm where its volume is 3.375 mm^3 and weight of the concrete is to be 8.44 kg. The cement, sand and coarse aggregate ratio is 1:2:4 with 0.45 w/c ratio. These specimens are tested by compression testing machine after 7 days and 14 days curing. Load should be applied gradually at the rate of 140 kg/cm^2 per minute till the specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Table.5.Compressive strength for 7 days and 14 days curing

Sample	7 Days		14 Days	
	Load (kN)	Stress (kN/m^2)	Load (kN)	Stress (kN/m^2)
A	368	15.36	460	20.44
B	474	18.24	562	24.97
C	455	17.49	531	23.69

3. RESULTS

Result analysis: From the above experimental results a chart is made to represent a pictorial analysis on the result for 7days and 14 days curing. Strength is more effective on sample replaced with 10% of flyash in cement. It is also expected to give more result on increased curing period.

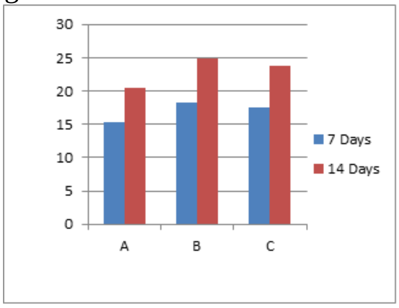

Fig.3.Compressive stress of concrete samples

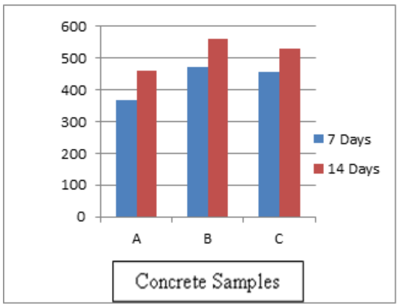

Fig.4.Load of concrete samples

Procedure of laying ballastless track: There are certain steps of procedure to lay soil stabilized ballastless track. For this project only soil filling and soil stabilization is done, the other steps are to be followed in future papers.

Step1:Preparation of substructure: A 5 layer of 250mm thick of soil fill material is laid on the ground as substructure. Vertical drains are also provided on this fill material.

Figure.5.Soil filling

Fiure.6.Vertical drains

Step 2: Laying of hydraulic bound layer: Hydraulic bound layer of 300mm is laid on the substructure. Hydraulic bound layer is prepared as per the design mix.

Figure.7.Hydraulic bound layer

Step.3.Testing of HBL: After laying HBL, the layer is tested for its settlement. Plate load test is to be carried out.

Step.4.Providing rails on the HBL: Rails are inserted in the hydraulic bound layer. It is provided without ballast and also without sleepers.

Step.5.Installation of track formwork: The tracks formwork is done after rails are laid on the HBL. The track is **aligned using equipment.**

Step.6: Supplementary working steps: After the track formation, concreting work is done. Supplementary work such as realigning of track is carried out.

4. CONCLUSION

In combination with hydraulic binders like flyash, sleeper track in unfit soil conditions may remain an attractive concept well into the 22nd century. With increased curing period, the strength of the layer is also increased. The compressive strength has proven to be effective with moderate replacement of flyash with cement. The future scope of the project is to determine the settlement by plate load test and to prove that ballastless track can be laid on the soil conditions.

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