STUDY ON COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE FOR UTILISATION AS PAVENENT

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ABSTRACT - *Pervious concrete is a concrete containing little or no fine aggregate; it consists of coarse aggregate and cement paste. It seems pervious concrete would be a natural choice for use in structural applications in this age of 'green building'. It consumes less raw material than normal concrete (no sand), it provides superior insulation values when used in walls, and through the direct drainage of rainwater, it helps recharge groundwater in pavement applications.*

Due to increase in construction and demolition activities all over the world, the waste concrete after the destruction is not used for any purpose which leads to loss of economy of the country. India is a developing country where urbanization is increasing rapidly which in turn leading to increase of drainage facilities.

Pervious concrete helps to allow the water flow into the ground due to interconnected pores.Natural aggregate are becoming scarce, production and shipment is becoming more difficult. In order to overcome this problem there is need to find a by-product, which can be used to replace the aggregate in conventional concrete mix.

The experiments were performed on specimens with different proportion of Demolition waste and Fly-ash. It is found out that compressive strength of M25 pervious concrete is b/w 4MPa to 20MPa.

This report helps to find out up to what extent Demolition waste and Fly-ash can be replaced for cement and aggregates so that the concrete doesn't lose its strength and other properties.

1. INTRODUCTION

Pervious concrete provide a level of porosity which allows water to percolate into the sub-grade. It differs from the conventional concrete since it usually contains a nominal or no amount of fine aggregate. Pervious concrete is comprised of single size aggregates which result in larger air voids than conventional concrete. It also known as porous concrete (enhanced porosity) or gap-graded concrete has little to no fine aggregates. Pervious concrete mixes consist of cement, single sized coarse aggregate and water (water/cement ratio ranging 0.27 to 0.30). It is reported that, the 28 day compressive strength of such mixes range from 4Mpa to 20Mpa based on compressive strength testing per ASTM C39. In addition, pervious concrete mixes vary among batch manufacturers with varying strengths and permeability rate.

The benefits from its use are its potential to:

- Reduce the amount of runoff water
- Improve quality of water
- Enhance pavement skid resistance, especially during storm by rapidly draining rain water
- Reduce traffic-induced noise levels

The main drawback of pervious concrete is, it cannot withstand load of large number of heavy vehicles but if it is designed properly means it can hold low volume of heavy vehicles. It provides high rate of permeability inspite of less and more compressive strength.

Cement is one of the main component used but production of cement leads to variour other problems such as air pollution, green house effect etc, therefore finding a alternative to cement is necessary. Fly-ash is one of the material which can be replaced with cement.Up to what extent we can use Fly-ash so that strength and other properties of pervious concrete does not alter we will find out in this thesis.

Steel slag which is obtained during steel manufacturing can be used as alternative to natural aggregates. The percentage of steel slag that as to be used as alternative to natural aggregates so that pervious concrete dos not lose its properties has to be found out.

Hence the scope of the present study is focused on determining the accuracy of the anecdotal evidence obtained from partial replaced concrete and studying the compressive strength of new material made of fly ash, cement, water, aggregates and steel slag.

The main objectives of this thesis are as follows:

1. Characteristics of fly ash and steel slag (coarse) .
2. To understand the behaviour of fly ash-cement with and without addition of steel slag with

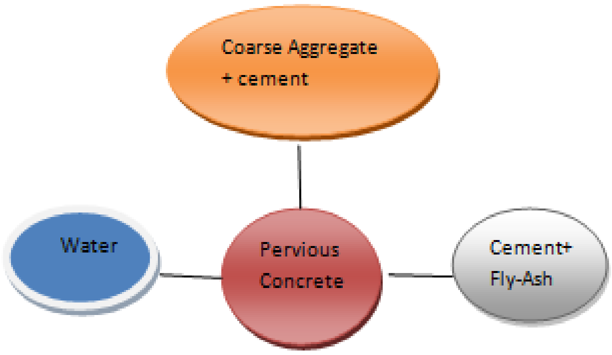
respective to its compressive strength for M-35 grade mix.

3. To understand the outcome of varying composition of steel slag on compressive strength developed by concrete specimens (M-35 grade) at room temperature.

1.1 LITERATURE REVIEW

Pervious concrete is first used in Europe in the nineteenth century for variety of purpose such as load bearing walls, paving etc. It later became popular in countries like Australia, Russia and Middle East. USA began to use it in the 1970's due to its permeability nature but this became problem due to runoff from newly construted areas which lead to erosion, flooding creating negative impact on environment. Although it had slow beginning and negative impact, it as developed into a multi-functional tool in the construction industry

2 MATERIALS AND METHOD



2.1 INTRODUCTION

In this section different materials which are used during this project are studied and also tested based on standard techniques

2.2 MATERIALS:

2.2.1 CEMENT:

Cement of 53 grades is used. Different properties of cement were found out based on IS 269-1976 and IS 4031-1988. Water cemen ratio is kept between .30 to 0.40. If the amount water becomes low then it leads to low binding, more percentage of water will decrease voids space and permeability nature.

2.2.2 COARSE AGGREGATE:

Crushed stone of nominal size 12.5mm is used. Aggregate with specific gravity of 2.77 and passing through 12.5mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

2.2.3 FLY-ASH:

The fly ash used during this project is taken from thermal power plant of Raichur. The type of fly ash is F. The location of station from which material is obtained is 16°21'18''N 77°20'31''E coordinates in the Raichur district of Karnataka state, India.

FIGURE 1 FLY ASH

2.2.4 WATER:

Potable water was used for the entire project.

2.3 CHARACTERISTICS OF FLY-ASH (FA):

2.3.1 SPECIFIC GRAVITY:

It is found out according to standard tests prescribed in Indian standards. By conducting the specific gravity test on Fly-ash the value got is 2.532.

2.3.2 CHEMICAL PROPERTIES:

The flyash chemical properties depends mainly on two things i.e on its source (burned coal) and type of techniques used in extracting and storing. Depending on its composition, heating value, ash content and origin, flyash can be classified in to different types. The main component of flyash is silica, calcium, varying percentage of carbon (measured by LOI) and iron oxide.

Lignite and sub bituminous coal flyash contains higher percent of ca and mgO and lower concentration of silica and Fe2O3,and also less content of carbon, compared to bituminous coal flyash.

Main difference b/w F class and class C flyash is concentration of ca and silica, alumina and Fe content in the ash. Class F contains upto 12% of calcium, mostly in the form of ca(OH)2, CaSO4 and glassy components along with silica and alumina. Class F contains less amount of alkalis and sulphates.

2.4 DEMOLITION WASTE:

Demolition waste is waste debris from destruction of buildings, roads, bridges, or other structures. Debris varies in composition, but the major components, by weight, include concrete, wood products, asphalt shingles, brick and clay tile, steel, and drywall.

The Debris for the present study is obtained from a nearby demolition site. The obtained Debris is sieved under Standard IS sieve to get 12.5 mm down size. The specific gravity is found to be in the range of 2.19–2.48

2.5 PREPARATION OF CONCRETE SPECIMEN:

1. Required quantity of aggregates and cement is taken by correctly weighing.
2. The weighed items are mixed in a tray for certain time until all the aggregates are in contact of cement
3. The amount of water calculated is taken in a measuring jar and it is added to the mix.
4. The aggregate, cement and water i thoroughly mixed before placing in the mould.
5. Mould of required size is taken and oil is applied to each innerside of the cube.
6. Mixed concrete is added to mould in three layers and each layer is tamped for 25 times with the help of tamping rod.
7. Concrete moulds are kept for 24 hrs and it is demoulded, then the cubes are placed in a water tank for certain duration.

FIGURE 2 WEIGHING REQUIRED MATERIALS

FIGURE 3 TAKING WEIGHED AGGREGATES IN A TRAY

FIGURE 4 DRY MIXING OF MATERIALS IN A TRAY

FIGURE 5 ADDING CALCULATED WATER

FIGURE 6 MIXING

FIGURE 7 PLACING CONCRETE MIX IN MOULD AND TAMPING

FIGURE 8 PREPARED MOULDS

FIGURE 9 CUBE TAKEN OUT FROM MOULD AFTER 24HRS

2.6 SAMPLE CURING:

Concrete specimens are cured according to standard procedure. Curing leads to development of strength and durability of mortar. It helps in maintaining required temperature and moisture for desired period of time.

FIGURE 10 PLACING CUBES FOR CURING

2.7 COMPRESSION STRENGTH TEST PROCEDURE FOR COMPACTED SPECIMEN.

- After curing is completed for specified period of time, the specimes are taken out of water and demoulded.
- The testing machine is cleaned and load is adjusted for 40KN/minute.
- Before placing the specimen, adjust the plate to the height of specimen.
- The specimen is placed into the machine.
- Value is closed.
- Load is applied on the cube at the rate of 40KN per minute until the cube is failed.
- Load at which the specimen fails is noted.

FIGURE 11 CUBE UNDER COMPRESSION TEST

2.8 MIX DESIGN FOR M25 PERVIOUS CONCRETE

a) Grade:M25

b) Max. nominal size of agg: 12.5mm

c) Min. cement content: 320kg/m^3

d) Max.w/c ratio: 0.30

e) Workability: 100mm (slump)

f) Exposure condition: Severe

g) Method of concrete placing: Pumping

h) Type of aggregate: Crushed angular aggregate

i) Max. cement content: 450 kg/m^3

Target strength of mix proportion.

$$f'_{ck} = f_{ck} + 1.65\ s$$

Where,

f'_{ck} = Target average compressive strength at 28th day,
f_{ck} = Characteristic compressive strength at 28th day,
s= Standard deviation

From Table 1of IS 10262:2009 standard deviation, s = 5 N/mm^2

Therefore target strength=35+1.65 x 5=38.15N/mm^2

SELECTION OF WATER CEMENT RATIO

From Table 5 of IS:456-2000, max. w/c ratio =0.30

As 0.33 < 0.45, hence ok

SELECTION OF WATER CONTENT

From Table-2 IS 10262:2009, max. water content=203 litres (for 25mm to 50mm slump range)

for 12.5mm aggregates

water content for 100 mm slump =186 + 6/100 x186 =215 litres

Calculation of cement content

w/c ratio =0.30

Cement content=215/0.30=716.66 kg/m^3

Since max. cement content is 425 kg/m^3

Hence adopting 370 kg/m^3

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table 3 of IS 10262:2009, volume of coarse aggregate corresponding to 12.5mm size aggregate for w/c ratio of 0.50 =0.48

Here w/c is 0.30. Vol. of coarse aggregate is required to be increased as there is no fine aggregate. As w/c ratio is lower by 0.20, increase the coarse aggregate volume by 0.04 Therefore revised vol. of coarse aggregate for w/c of 0.30 =0.52

Since concrete is pumped so value is decreased by 10%
Hence vol. of coarse aggregate=0.90

MIX CALCULATIONS

a) Vol. of concrete =1m^3

b) Vol.of cement =[370/3.15]x[0.0001]=0.1175m^3

c) Vol. of water=[215/1]x[0.0001]=0.215m^3

d) Vol.of all in aggregates (e)=a – (b + c + d)=1– (0.1175 + 0.215)=0.6675m^3

e) Mass of coarse aggregates = d x Vol. of CA x sp.gravity of CA = 0.6675x0.90x2.74x1000=1646 kg

MIX PROPORTIONS

Cement=370 kg/m^3

Water=215 kg/m^3

Coarse aggregates=1646 kg/m^3

w/c ratio=0.30

Mix proportion:

Cement: CA = 370/370:1646/370

= 1: 4.45

2.9 MIX CALCULATION FOR M25 PERVIOUS CONCRETE SUBSTITUTING FLY-ASH FOR CEMENT:

a) Vol. of concrete =1m^3

b) Vol. of cement=[370/3.15]x[0.0001]=0.1175m^3

c) Vol. of water=[215/1]x[0.0001]=0.215m^3

d) Vol. of all in aggreagtes (d) =a–(b+c+d)=1–(0.1175+0.215) = 0.6675m^3

e) Mass of coarse aggregates = dxVol. of CAxsp.gravity of CA
=0.6675x0.90x2.74x1000=1646kg

2.9.1 FOR 30% FLY-ASH AND 70% CEMENT

Cement=259kg/m^3

Fly ash=111kg/m^3

Water=215kg/m^3

Coarse aggregates=1646kg/m^3

w/c ratio=0.30

Mix proportion:

Cement: CA: Fly-ash = 259/370: 1646/370: 111/370 = 0.7:4.45:0.3

FIGURE 12 PERVIOUS CONCRETE CUBES WITH 30%FA+70%CEMENT

2.9.2 FOR 50% FLY-ASH AND 50% CEMENT

Cement=185kg/m^3

Fly ash=185kg/m^3

Water=215kg/m^3
Coarse aggregates =1646 kg/m^3

w/c ratio=0.30

Mix proportion:

Cement:CA:Flyash=185/370:1646/370:185/370 =0.5:4.45:0.5

FIGURE 13 PERVIOUS CONCRETE CUBES WITH 50%FA+50%CEMENT

2.9.3 FOR 70% FLY-ASH AND 30% CEMENT

Cement=111kg/m^3

Flyash=259kg/m^3

Water=215kg/m^3

Coarse aggregates=1646 kg/m^3

w/c = 0.30

Mix proportion:

Cement:CA:Fly-ash =111/370:1646/370:259/370 = 0.3:4.45:0.7

FIGURE 14 PERVIOUS CONCRETE CUBES WITH 70%FA+30%CEMENT

2.10 MIX CALCULATION FOR M25 PERVIOUS CONCRETE SUBSTITUTING DEMOLITION WASTE FOR COARSE AGGREGATE:

a) Vol. of concrete=1m^3

b) Vol. of cement=[370/3.15]x[0.0001]=0.1175m^3

c) Vol. of water=[215/1]x[0.0001]=0.215m^3

d) Vol. of all in aggregates (d)=a–(b+c+d)=1–(0.1175+0.215)=0.6675m^3

e) Vol. of coarse aggregates=dxVol. of CAxspecific gravity of CA =0.6675x0.90x2.74x1000=1646kg

2.10.1 FOR 30% DEMOLITION WASTE AND 70% COARSE AGGREGATE:

Cement=370kg/m^3

Water=215 kg/m^3

Coarse aggregates=1152kg/m^3

Demolition Waste =494kg/m^3

w/c ratio=0.30

Mix proportion:

Cement: CA: Demolition Waste = 370/370:1152/370:494/3 = 1:3.11:1.34

2.10.2 FOR 50% DEMOLITION WASTE AND 50% COARSE AGGREGATE:

Cement=370kg/m^3

Water=215kg/m^3

Coarse aggregates=823kg/m^3

Demolition Waste =823kg/m^3

w/c ratio=0.30

Mix proportion:

Cement: CA: Demolition Waste = 370/370:823/370:823/370 = 1:2.225:2.225

2.10.3 FOR 70% DEMOLITION WASTE AND 30% COARSE AGGREGATE:

Cement=370kg/m^3

Water=215kg/m^3

Coarse aggregates=494kg/m^3

Demolition Waste =1152kg/m^3

w/c ratio=0.30

Mix proportion:

Cement: CA: Demolition Waste = 370/370:494/370:1152/370 = 1:1.34:3.11

3 RESULT AND ANALYSIS

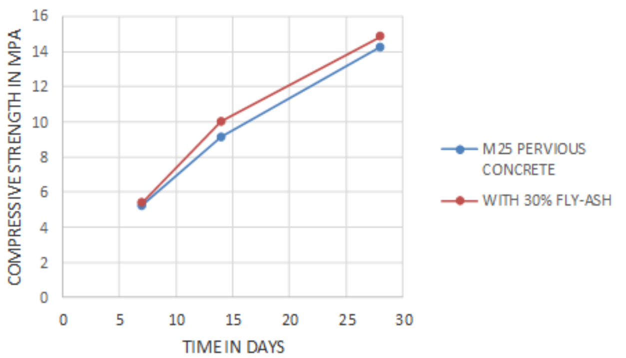
3.1 INTRODUCTION:

In this section study of compressive strength based on different curing time on different ratio of flyash and Demolition Waste is compared. Compressive strength developed for different variations of flyash and Demolition Waste is found out. Cement is compenseted by 30%, 50% and 70% fly-ash and coarse aggregate by 50%, 70% and 100% Demolition Waste . Specimens with mentioned percentage of flyash and Demolition Waste are prepared. Curing of prepared specimens are carried out for specified period of time. After the specified time of curing, the compressive strength of cubes are calculated.

3.2 EXPERIMENTAL RESULTS AND ANALYSIS FOR CONCRETE SPECIMENS:

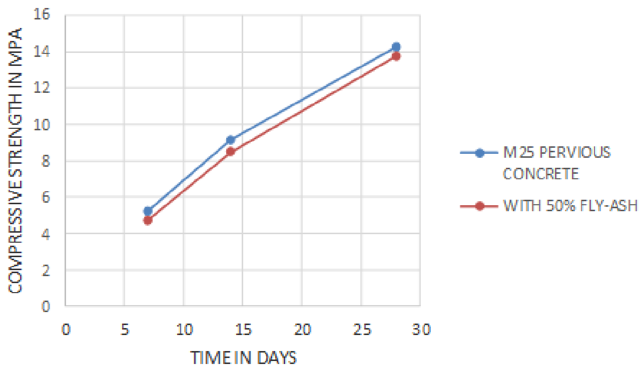
3.2.1 COMPRESSIVE STRENGTH ANALYSIS FOR 30% REPLACEMENT OF FLY-ASH (FA) WITH CEMENT:

Pervious concrete mix M25 showed compressive strength of 5.23 MPa, 9.13 MPa and 14.24 MPa for 7,14 and 28 days of curing. 30% FA added concrete shows 5.28 MPa,16.47MPa and 18.3MPa compressive strength for 7, 14 and 28 days. These values indicate that 30% FA added concrete shows better compressive strength when compared with other mix proportions.



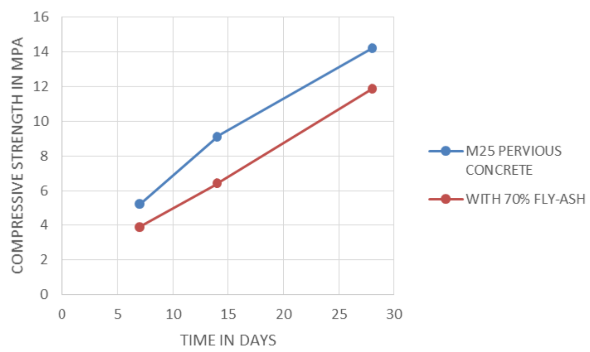
3.2.2 COMPRESSIVE STRENGTH ANALYSIS FOR 50% REPLACEMENT OF FLY-ASH WITH CEMENT:

The following table gives compressive strength results for concrete added with 50% of FA content. The values shows that 50% FA added concrete showes compressive strength of 5.01 MPa, 8.47 MPa and 14.24 MPa for 7, 14 and 28 days of curing respectively. This indicates 50 percent addition of flyash in place of cement does not add much to the compressive strength.



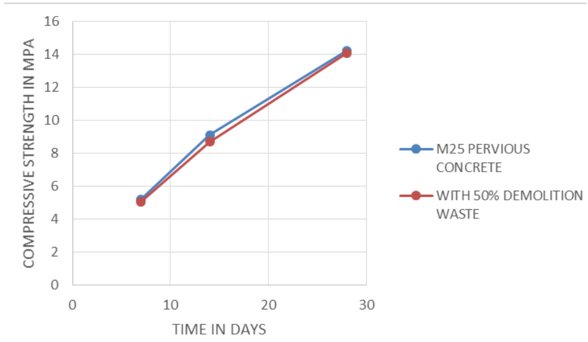
3.2.3 COMPRESSIVE STRENGTH ANALYSIS FOR 70% REPLACEMENT OF FLY-ASH WITH CEMENT:

The values shows that 70% FA added concrete shows 3.9 MPa, 6.41 MPa and 11.9 MPa for 7, 14 and 28 days of curing respectively. The value signifies that 70% addition of fly-ash in place of cement will tends to lower the compressive strength.



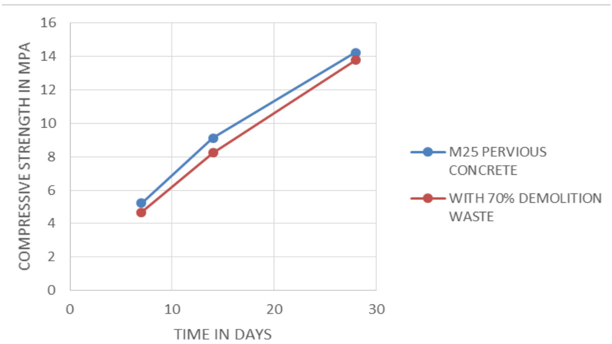
3.2.5 COMPRESSIVE STRENGTH ANALYSIS FOR 50% REPLACEMENT OF DEMOLITION WASTE WITH COARSE AGGREGATE (CA)`:

Here Demolition waste content is added 50% by volume of coarse aggregate and samples are prepared at a water cement ratio of 0.35. Pervious concrete mix M25 showed compressive strength of 5.06 MPa, 8.7 MPa and 14.11 MPa for 7, 14 and 28 days of curing.



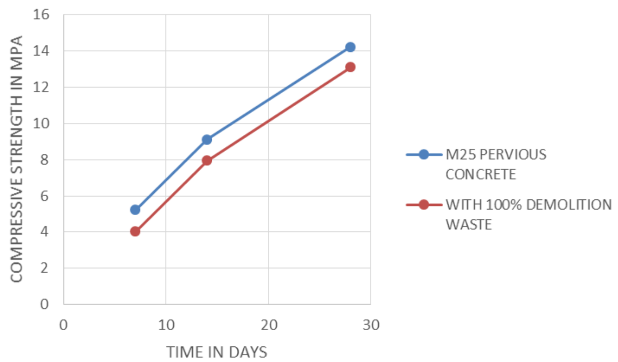
3.2.6 COMPRESSIVE STRENGTH ANALYSIS FOR 70% REPLACEMENT OF DEMOLITION WASTE WITH COARSE AGGREGATE (CA)`:

Here Demolition waste is added 70% by volume of coarse aggregate and specimens are made. Pervious concrete mix M25 showed compressive strength of 4.67 MPa, 8.23 MPa and 13.79 MPa for 7, 14 and 28 days of curing..



3.2.7 COMPRESSIVE STRENGTH ANALYSIS FOR 100% DEMOLITION WASTE:

Here 100% Demolition Waste is used in place of coarse aggregate. The strength of these type of cubes is little less than that of normal pervious concrete cubes. Pervious concrete mix M25 showed compressive strength of 4.03 MPa, 7.49 MPa and 13.11 MPa for 7, 14 and 28 days of curing and same is shown in below graph.



4 CONCLUSION

4.1 GENERAL CONCLUSIONS:

The following results were obtained for fly ash and demolition waste incorporated pervious concrete.

1. Results showed that with 30% FA added concrete shows 5.28 MPa,16.47MPa and 18.3MPa compressive strength for 7, 14 and 28 days. These values indicate that 30% FA added concrete shows better compressive strength when compared with other mix proportions.

2. The values shows that 50% FA added concrete showes compressive strength of 5.01 MPa, 8.47 MPa and 14.24 MPa for 7, 14 and 28 days of curing respectively. This indicates 50 percent addition of flyash in place of cement does not add much to the compressive strength.

3. The values shows that 70% FA added concrete shows 3.9 MPa, 6.41 MPa and 11.9 MPa for 7, 14 and 28 days of curing respectively. The value signifies that 70% addition of fly-ash in place of cement will tends to lower the compressive strength.

4. Demolition waste content is added 50% by volume of coarse aggregate and samples are prepared at a water cement ratio of 0.35. Pervious concrete mix M25 showed compressive strength of 5.06 MPa, 8.7 MPa and 14.11 MPa for 7, 14 and 28 days of curing..

5. Demolition waste is added 70% by volume of coarse aggregate and specimens are made. Pervious concrete mix M25 showed compressive strength of 4.67 MPa, 8.23 MPa and 13.79 MPa for 7, 14 and 28 days of curing..

6. Here 100% Demolition Waste is used in place of coarse aggregate. The strength of these type of cubes is little less than that of normal pervious concrete cubes. Pervious concrete mix M25 showed compressive strength of 4.03 MPa, 7.49 MPa and 13.11 MPa for 7, 14 and 28 days of curing and same is shown in below graph.

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