

# The Study of Infiltration Rate in Solid Waste Porous Concrete Tiles Using Building Demolition Waste

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**Abstract**—The present study reveals the details of rate of infiltration of porous concrete tiles. The concrete used here is no fines concrete. Coarse aggregates (CA) are replaced partially by building demolition waste- brick bats (BB) and debris concrete matrix (SC) and their combination by 50:50 replacement. An attempt is made to know the permeability characteristics of porous concrete tiles by conducting infiltration test. Four different combinations of mix design proportions (M1, M2, M3 and M4) are used to know the rate of infiltration as per ASTM C1701/C1701M test method. The cost of porous concrete is compared to conventional concrete along with caution, placing and applications of concrete tiles.

**Keywords**—infiltration rate, solid waste, mix design, building demolition waste, porous concrete, permeability

## I. INTRODUCTION

Considerable and notable research has been done in past and present on environmentally sustainable development. Builders, designers and researchers are always looking for innovative and new effective methods to safeguard the environment in all possible ways. The use of porous materials for concrete is one of the emerging technologies, as an alternate material.

Demolition waste is waste debris from destruction of a building. Building demolition waste is defined as the solid waste generated by demolition, repair, alteration, renovation and construction of residential, commercial, government and institutional buildings. Building waste can be considered as a resource. These materials can be used in concrete in spite of using it as landfills.

The concrete is impervious in nature used for the construction of foot paths, pavements contributes to the increase in water runoff to the drainage, causing excessive flooding in built-up area due to raise in infrastructure and activities. With the changing climatic conditions and increasing urbanization had resulted in flooding of major cities.

Pervious concrete which is engineered concrete to have very high permeability to allow the rain water to drain rapidly.

Pervious concrete is a special concrete with high permeability compared to conventional concrete due to voids in concrete structure. Porous concrete is also called as permeable concrete, gap graded concrete and pervious concrete. It can be produced by cement and all types of coarse aggregates, without fines.

- To develop the mix design proportions using various percentage of virgin coarse aggregate from local quarry, coarse aggregate and brick ballast from demolished masonry wall, building demolished waste from slab, beams, lintel and rubble of column (Ashraf M, *et al.*, 2013).
- To investigate the infiltration property of porous concrete.
- Infiltration test is conducted on pervious concrete tiles.

## II. MATERIALS AND TESTS

In this investigation, the following materials are used to prepare porous concrete to cast the tiles.

- Cement: Ordinary Portland cement 53 grade is used. Ordinary Portland cement conforming to IS 12269-1987
- Coarse aggregate (CA), coarse aggregates (20mm downsize material) are used conforming to IS 383:1970.
- Recycled coarse aggregate (RA) and Building demolition waste (BDW) comprising of demolished walls and concrete slab/beams and columns. The mortar material from the demolished wall is separated and only bricks/ brick bats (BB) are used for the investigation. In the slab/beams and columns reinforcement is separated and only the concrete matrix (SC) is used for this investigation. The materials separated are screened, cleaned, sieved and soaked in water and used as coarse aggregate conforming to IS 383:1970
- Super plasticizer conplast SP-430 is added by 1% to increase the workability (optional).

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- For the Coarse aggregate (CA) and Recycled coarse aggregate (RA) and Brick ballast (BB) tests such as specific gravity, aggregate impact and aggregate crushing test are conducted to understand its properties.
- Water: water to be used for mixing and curing shall conform to IS 456:1978.
- Table 1, 2 and 3 gives the physical properties of coarse aggregate, building demolition waste (SC) and brick ballast respectively.
- The above properties satisfies the requirements as per previous investors (Malhotra, V. M. 1976 and Jing Yang and Guoliang Jiang. 2003)

**III. INFILTRATION OF TILES**

The test is conducted as per ASTM C1701/C1701M-09. It is the quantity of water that can be percolated into the tile of prescribed dimension in t seconds. The procedure is as below

1. Cast the tiles of desired mix proportion of concrete using standard mould of size (300 x 300 x 25) mm (Figure 3.10).
2. Place four tiles 2No x 2 No. square shape of size 600mmx600mm.
3. Construct a wall around the tiles, ensuring no leakage and pre wet the tiles.
4. Standard quantity of 18 liters of water is poured on the tiles, through infiltration ring of ring of 300mm diameter.
5. Time taken to percolate water into the tiles is noted.

**IV. MOULD OF TILE AND CASTING OF TILES**

Following formula is used to find infiltration:

To calculate the rate of infiltration (I) using consistent following units:

$$I = (K \cdot M) / (D^2 \cdot t) \dots\dots\dots \text{Eq. 1}$$

The terms are

- I = Rate of infiltration, mm/h [in./h]
- M = Mass of water, kg [lb]
- D = Diameter of infiltration ring, mm [in],
- t = time required for water to infiltrate into the concrete
- K = 4583666000 in SI units or 126870 in [inch-pound] units

The standard moulds for casting porous concrete tile is shown in figure 1.

**V. CODES FOR MIX DESIGN**

IS 10262: 2009 concrete mix proportioning –guidelines  
 IS 456: 2000 plain and reinforced concrete –code of practice. The mix design proportion for various combination CA:BB, CA:BB+SC and CA:SC are tabulated in Table 4, 5 and 6 respectively. The results obtained in the present study are given in Table 7, 8, 9 and Figure 2.

It is observed that for CA:BB, infiltration rate is maximum compared to other combinations, because porosity of brick bat is maximum (Md Tanvir Hosain, *et al.*, 2012).

**TABLE 1  
PHYSICAL PROPERTIES - COARSE AGGREGATE**

Physical Properties	Value	Permissible limits( IS code)
Specific gravity	2.65	----
Water absorption in %	0.3	----
Bulk density in Kg/m <sup>3</sup>	1480	---
Crushing value in %	27	Should be < 30
Impact value in %	18	Should be < 30
Abrasion value in %	12.2	Should be < 30
Flakiness- index	11.92	Should be < 30
Elongation- index	29.7	---

**TABLE 2  
PHYSICAL PROPERTIES - BUILDING DEMOLISHED WASTE**

Physical Properties	Result
Specific gravity	2.51
Water absorption in %	4.54
Sieve analysis	Conforming to Table 2 of IS 383-1970
Crushing value in %	35.26
Impact value in %	27.44

**TABLE 3  
PHYSICAL PROPERTIES - BRICK BALLAST (BB)**

Physical Properties	Result
Specific gravity	2.09
Water absorption (%)	11.8
Sieve analysis	Conforming to Table 2 of IS 383-1970
Crushing value (%)	28.55
Impact value (%)	23.69



**FIGURE 1 STANDARD MOULD FOR TILES**

**TABLE 4.**  
**MIX DESIGN FOR POROUS CONCRETE WITH CA: BB COMBINATION**

Mix	W/C Ratio	Proportion		Weight in kg /m <sup>3</sup>					Mix Proportion
		CA %	BB %	Cement (Kg)	Water (L)	CA (Kg)	BB (Kg)	Super Plasticizer (Kg)	
M1	0.4	50	50	350	140.0	984.7	776.6	3.5	1:2.81:2.22
M2	0.45	50	50	311.1	140.0	1001.9	794.0	3.1	1:3.22:2.55
M3	0.5	50	50	280.0	140.0	1014.9	882.8	2.8	1:3.62:3.15
M4	0.6	50	50	233.3	140.0	1035.19	900.3	2.3	1:4.44:3.85

**TABLE 5**  
**MIX DESIGN FOR POROUS CONCRETE WITH CA: SC+BB COMBINATION AS PER IS 10262:2009 GUIDELINES**

Mix	W/C Ratio	Proportion		Weight in kg /m <sup>3</sup>					Mix Proportion	
		CA %	SC %	Cement (Kg)	Water (L)	CA (Kg)	SC (Kg)	BB (Kg)		Super Plasticizer (Kg)
M1	0.4	50	50	350	140	984.7	466.3	390.1	3.5	1:2.8:2.44
M2	0.45	50	50	311.1	140	1001.9	474.5	397.0	3.1	1:3.22:2.80
M3	0.5	50	50	280.0	140	1014.9	480.6	402.1	2.8	1:3.62:3.15
M4	0.6	50	50	233.3	140	1035.1	490.2	410.1	2.3	1:4.43:3.85

**TABLE 6**  
**MIX DESIGN PROPORTIONS FOR CA: SC**

Mix	W/C Ratio	Proportion		Weight in kg /m <sup>3</sup>					Mix Proportion
		CA %	SC %	Cement (Kg)	Water (L)	CA (Kg)	SC (Kg)	Super Plasticizer (Kg)	
M1	0.4	50	50	350	140.00	984.47	932.4	3.50	1:2.81:2.66
M2	0.45	50	50	311.11	140.00	1003.0	950.0	3.11	1:3.22:3.05
M3	0.5	50	50	280.00	140.00	1016.2	962.5	2.80	1:3.62:3.43
M4	0.6	50	50	233.33	140.00	1036.1	981.4	2.33	1:4.44:4.20

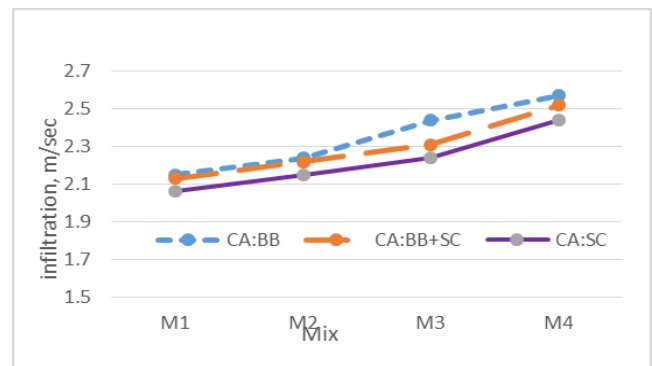
**TABLE 7**  
**INFILTRATION RATE OF TILES FOR CA AND BB MIX DESIGN**

Mix	Mix Proportion, C:A	Water/ Cement Ratio	Cement kg	Water L	CA %	BB %	Time(s)	Infiltration Rate 10-3 (m/s)
M1	1:2.81:2.22	0.4	350	140	50	50	118	2.15
M2	1:3.22:2.55	0.45	311.1	140	50	50	113	2.24
M3	1:3.62:3.15	0.5	280	140	50	50	104	2.44
M4	1:4.44:3.85	0.6	233.3	140	50	50	99	2.57

*C=Cement, A=Aggregate, CA= Coarse Aggregate, BB= Brick Ballast, SC= Slab/beam/column concrete,*

**TABLE 8**  
**INFILTRATION RATE OF TILES OF SC AND BB MIX DESIGN**

Mix	Mix Proportion C:A	Water/ Cement Ratio	Cement kg	Water L	CA %	SC+BB %	Time (s)	Infiltration Rate 10-3 m/s
M1	1:2.80:2.44	0.4	350	140	50	50	120	2.13
M2	1:3.22:2.80	0.45	311.11	140	50	50	115	2.22
M3	1:3.62:3.15	0.5	280	140	50	50	111	2.31
M4	1:4.43:3.85	0.6	233.33	140	50	50	101	2.52



**FIGURE 2 INFILTRATION RATE IN POROUS TILES FOR VARIOUS MIX COMBINATIONS**

**TABLE 9**  
**INFILTRATION RATE OF TILES OF CA AND SC MIX DESIGN**

Mix	Mix Proportion (C:A)	Water/ Cement Ratio	Cement (Kg)	Water (L)	CA %	SC %	Time (S)	Infiltration Rate 10-3 m/s
M1	1:2.81:2.66	0.4	350	140	50	50	124	2.06
M2	1:3.22:3.05	0.45	311.11	140	50	50	118	2.15
M3	1:3.62:3.43	0.5	280	140	50	50	114	2.24
M4	1:4.44:4.20	0.6	233.33	140	50	50	104	2.44

## VI. CONCLUSION

- Infiltration is a major influencing factor in the present study. M4 concrete mix of combination CA: BB with cement ratio 0.6 of proportion 50:50 is recommended where it meets peak permeability characteristics (Figure 2).
- When moderate strength and permeability characteristics are desired, mix M1, M2 and M3 of mix design concrete tiles of CA: SC+BB combinations, are suggested.

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- For moderate strength and low permeability all combinations viz. CA:BB, CA:SC+BB and CA:SC porous concrete tiles are suggested.
- Cost analysis of the porous concrete for combinations 50:50 was analyzed and reduction of cost by 36% was observed when compared to conventional plain concrete.
- A caution for the use of porous concrete tile is that, pervious concrete tiles shall be used only for non-traffic areas like foot paths, park yards, zoo area and bed of reservoirs. Further, it is placed with light compaction at moderate temperature, in addition regular maintenance is required for effective infiltration process (Bleedens, A *et al.*, 2003 and Tennis, Paul, D *et al.*, 2004).

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