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Mix Design for Concrete with Crushed Ceramic Tiles as Coarse Aggregate

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Abstract

Due to the increasing demand of construction material and degradation of environment, there is need to explore alternative construction material from industrial as well as household waste and recyclable materials. Ceramic tiles are often dumped as waste material after it becomes useless. But it can e recycled and can be used as a construction material in present world which is seeking for alternative construction materials which are economical, environment friendly as well as provides same quality as that of a normal aggregate made of stones. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing these materials in house construction. A simple method of concrete mix design based on compressive strength of normal weight and crushed coconut shell aggregate concrete mixes is described in this paper.

1. Introduction

India ranks in the top 3 list of countries in terms of tile production in the world. The production during 2011-12 stood at approx. 600 million square meters. This huge production of ceramic tiles is due to the boom in housing sector coupled by government policies fuelling strong growth in housing sector. This huge amount of ceramic tiles are not recycled but is often used as pavement material or landfill. Ceramic tile aggregates are hard having considerable value of specific gravity, rough

surface on one side and smooth on other side, having less thickness and are lighter in weight than normal stone aggregates.Using ceramic tile aggregate in concrete not only it will be cost effective, but also provide considerable strength to the concrete. The ceramic tiles will also show more In the following mix design of M25 grade concrete, normal weight aggregate has been replaced by coconut shell aggregate and their respective calculation has been done.

2. Mix Design Detail

The mix design for M25 grade concrete is done as recommended in IS 10262-1982 and according to IS 10262-1982 the following data is required for concrete mix design.

1.	**Characteristic compressive strength at 28 days**	**25N/mm**
2	Cement	Cement used is PPC(fly ash based) according to IS 1489 : 1991(part 1) Fineness - 300m2/kg Compressive strength of 28 days – 33MPa Soundness according to Le Chatelier method – 10mm.
3	Coarse Aggregate .	Crushed ceramic tile aggregate of maximum nominal size of 20mm. With Specific gravity- 2.33
4	Fine aggregate	River sand was used as the fine aggregate conforming to grading zone II as per IS 383:1970 [159]. Specific gravity- 2.65
5	Maximum free water cement ratio	0.47
6	Workability corresponding to compaction factor	80mm slump.
7	Admixture	No admixture added.

3. Procedure for Mix Design

Following is the procedure for mix design as recommended in IS 10262 – 1982 as prescribed below:

- Determination of target characteristic compressive strength.
- Selection of free water cement ratio.
- Determination of free water content.

- Determination of cement content.
- Computation of total absolute volume of aggregates.
- Determination of fine and coarse aggregate content.

4. Design Mix

- Target mean strength for M25 mix design(F_t) is given by
  $F_t = F_{ck} + k.S$, where F_{ck} is characteristic compressive strength,
  K is constant and is taken as 1.65 and S is standard deviation.
  Therefore, F_t= 25 + 1.65*4.0 =31.6MPa.
- Free water cement ratio for target mean strength of 31.6MPa is 0.47.

Now according to IS 10262 - 1982 , for w/c ratio of 0.60 and max. nominal size of aggregate of 10mm,

- Air content of 2% is estimated according to the nominal maximum size of aggregate of 10mm.
- Water content per cubic metre of concrete with respect to nominal maximum size of aggregate of 20mm is 186kg.
- Proportion of sand of total aggregate by absolute volume = 35%.
- Adjustments in sand proportion:
  For w/c ratio of 0.47,
  Change in w/c ratio= 0.60-0.47=0.13
  Percentage reduction in sand = $\frac{0.13}{0.05}$ = 2.6%
  Final sand content = (35-2.6)% = 32.4%
- Calculation of cement content:
  Minimum cement content = $\frac{\text{final water content}}{\text{free water cement ratio}}$
  $= \frac{186}{0.47}$
  $=395.744 kg/m^3$
- Calculation for total absolute volume of aggregates:
  $Va = 1 - (v + \frac{w}{1000} + \frac{c}{Sc*1000})$
  Where, w= mass of water (kg), C= mass of cement(kg), V= air content (m^3),
  V= air content (m^3), Sc = specific gravity of cement.
  $Va = (\frac{2}{100} + \frac{186}{1000} + \frac{395.744}{3.15*1000})$
  $= 0.331 m^3$
  Volume of fine aggregate = $\frac{32.4}{100} * 0.331$ = 0.107 m^3.
  Volume of coarse aggregate = 0.331-0.107= 0.224m^3.

Mass of fine aggregate = (2.65*1000)*0.107 = 283.55 Kg/m^3.
Mass of coarse aggregate = (2.33*1000)*0.224 = 521.92 Kg/m^3.

5. Result

Based upon the above mix design,following mix proportion has been calculated :

Mass of cement (Kg/m^3)	**Mass of water (Kg/m^3)**	**Mass of coarse aggregate(crushed ceramic tiles) (Kg/m^3)**	**Mass of fine aggregate (Kg/m^3)**
395.74	186	521.92	283.55
1	0.47	1.31	0.71

- The final mass ratio of cement, water, coarse aggregate and fine aggregate is 1:0.47:1.31:0.71.

6. Conclusion

The following conclusions have been drawn:

(1) By using the ceramic tile aggregate, the mass of aggregate reduces about 50 % which in turn reduces the weight of concrete.

(2) Ceramic waste can be used as coarse aggregate as the properties of ceramic waste coarse aggregate are within the range of the values of concrete making aggregate according to Indian Standards.

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