ISSN: 2278-5213

SHORT COMMUNICATION

Demolished waste as coarse aggregate in concrete

Mohd Monish[1], Vikas Srivastava[1], V.C. Agarwal[1], P.K. Mehta[2] and Rakesh Kumar[2]
[1]Civil Engg. Department, SHIATS (formerly AAI-DU), Allahabad-211007, UP, India
[2]Civil Engg. Department, MNNIT, Allahabad-211004, UP, India
vikas_mes@rediffmail.com; +91 9415369170

Abstract

Huge quantities of construction and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because it requires huge space for its disposal and very little demolished waste is recycled or reused. This study is a part of comprehensive program wherein experimental investigations have been carried out to assess the effect of partial replacement of coarse aggregate by demolished waste on workability and compressive strength of recycled concrete for the study at 7 and 28 d. The compressive strength thus, observed was compared with strength of conventional concrete. Test results showed that the compressive strength of recycled concrete up to 30% coarse aggregate replacement (C. A. R.) by demolished waste at the end of 28 d has been found to be comparable to the conventional concrete.

Keywords: Demolished wastes, workability, compressive strength, recycled concrete, coarse aggregate.

Introduction

Huge quantities of construction materials are required in developing countries due to continued infrastructural growth and also huge quantities of construction and demolition wastes are generated every year in developing countries like India. The disposal of this waste is a very serious problem because on one side it requires huge space for its disposal while on the other side it pollutes the environment. It is also necessary to protect and preserve the natural resources like stone, sand etc. Continuous use of natural resources, like river and sand is another major problem and this increases the depth of river bed resulting in drafts and also changing the climatic conditions. So, the sustainable concept was introduced in construction industry due to growing concern about the future of our planet, because it is a huge consumer of natural resources as well as waste producer.

The proportion of concrete rubbles is maximum in the demolition waste. It has been reported by several researchers (Hansen, 1992; Mehta and Monteiro, 1993; Collins, 1994; Sherwood, 1995) that the crushed concrete rubble can be used as a substitute of natural coarse aggregates in concrete or as a sub-base or base layer in pavement, after separating these from the construction and demolition wastes. Some construction projects have been successfully completed using the recycled aggregates (Desmyster and Vyncke, 2000). Hendricks and Pieterson (1998) prepared concrete in which up to 20% natural aggregate was replaced with recycled aggregate and noticed a little effect on the properties of resulting concrete and that the concrete strength decreases when recycled aggregate was used. However, Dhir *et al.* (1999) reported that there is no decrease in strength for concrete containing up to 20% fine or 30% coarse recycled aggregates, but beyond these levels, there was a systematic decrease in strength as recycled aggregate content was increased. The strength parameters were not affected by the quality of recycled aggregate at high water/cement ratio; however, they were affected only when the water/cement ratio was low (Ryu, 2002; Padmini *et al*., 2002). A Lesser reduction in compressive strength of recycled aggregate concrete is reported at higher water/cement ratio (Dhir *et al*., 1999; Ryu, 2002; Chen *et al*., 2003). The rate of strength development in concrete containing crushed concrete or crushed brick is higher than that of referral concrete indicating further cementing action in presence of fine recycled aggregate, beyond the 28 d of curing (Khatib, 2005). Khalaf and DeVenny (2004) concluded that concrete can be successfully produced using recycled aggregates that have been produced from demolition and construction waste. Concrete produced with these aggregates does not perform so well, as concretes produced with natural aggregates in terms of strength. However, the concrete still has a strength that would make it suitable for some applications with the added benefit that density values are much lower; making it suitable in situations where self-weight is a problem and very good fire resistance is required.

Materials and methods

Demolished waste: Demolished waste was collected from IIT Building near Jhalwa, Allahabad. Demolished waste on being tested in laboratory, showed pozzolanic properties. Demolished waste as a pozzolanic material was used to partially replace coarse aggregate.

Colour of recycled aggregates used in the present investigation was pinkish brown, specific gravity and water absorption was 2.5 and 3-4.5 respectively.

Cement: Ordinary Portland cement of Birla (43 grade) brand obtained from a single batches trough out the investigation was used. The ordinary cement content contains mainly two basic ingredients namely argillaceous and calcareous. The physical properties of OPC as determined are shown in Table 1. The cement satisfies the requirement of IS: 8112-1989.

Fine aggregate: Fine aggregate is obtained from locally available river sand, which is passed through 4.75 mm sieve. The fineness modulus of fine aggregate was 2.74 and specific gravity was 2.63.

Coarse aggregate: Coarse aggregate was obtained from locally available crushed stone aggregate about 12 mm maximum of single lot size has been used trough out the experiment. Specific gravity of the coarse aggregate was 2.64 and the fineness modulus of coarse aggregate was 6.22.

Water: Potable water is used for mixing and curing. On addition of higher percentage of demolished waste, the requirement of water increases for the same workability. Thus, a constant slump has been the criteria for water requirement, but the specimens having 0% demolished waste, W/C of 0.50 has been used for the study.

Concrete: The concrete mix design was done in accordance with IS:10262 (1982). The cement content in the mix design was taken as 380 kg/cu m^3 which satisfies minimum requirement of 300 kg/cu m in order to avoid the balling effect. Good stone aggregate and natural river sand of zone-II was used as coarse and fine aggregate respectively. Maximum size of coarse aggregate was 12.5 mm and a sieve analysis conforming to IS:383-1970 was carried out for both the fine and coarse aggregate.

This study is a part of comprehensive programme wherein experimental investigations have been carried out to assess the effect of replacement of regular material by a cheaper substitute i.e., demolished waste on strength of concrete. For this study, cubes of 100 mm size were cast by replacing coarse aggregate by demolished waste. Compressive strength of this recycled concrete were observed and compared with those of natural aggregate concrete. To achieve this comparative study, cubes were cast replacing coarse aggregates by 10%, 20%, and 30% with demolished waste with respect to conventional concrete. These specimens were tested after 7 and 28 d and to identify cube strength, a mix proportion of 1:1.67:3.33 were used during the investigation.

Table 1. Properties of cement.

Properties	Requirement as per IS:8112-1989	Observed values
Normal consistency	-	28%
Initial setting time	30 min (min)	113 Min
Final setting time	600 min (max)	317 Min
3 d compressive strength	23 N/mm^2	23.67 N/mm^2
7 d compressive strength	33 N/mm^2	34.67 N/mm^2
28 d compressive strength	43 N/mm^2	44 N/mm
Soundness test	10 mm	2.5 mm
Fineness test (90µ sieve)	<10%	0.98%

Table 2. Slump and average compressive strength of concrete.

Types of concrete	Average compressive strength (N/mm^2)		Slump (mm)
	7 d	28 d	
Conventional concrete (0% DW)	33	38	30
10% C.A.R. concrete	32	36	22
20% C.A.R. concrete	29	35	26
30% C.A.R. concrete	25	33	25

Fig. 1. Workability of various percentage of C.A.R. concrete.

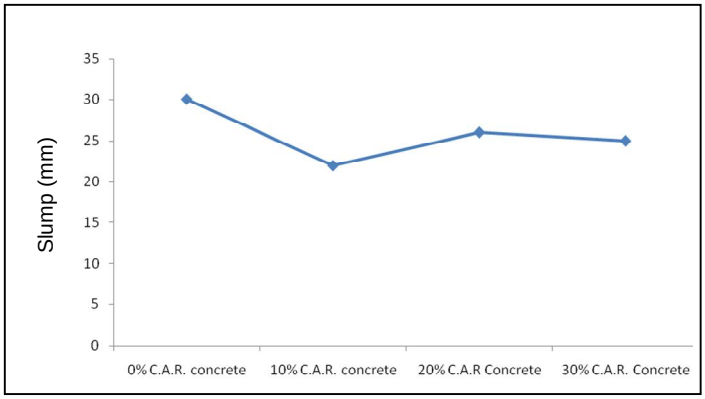
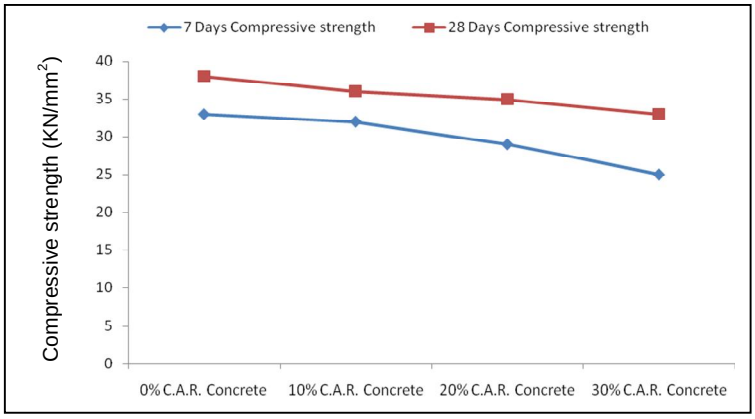


Fig. 2. Compressive strength of various percentage of C.A.R concrete.



Results and discussion

The observations made during the test of cubes are summarized as workability and compressive strength are presented in Table 2, Figure 1 and 2. Three specimens each having 0%, 10%, 20%, and 30% demolished waste as coarse aggregate replacement for mix of 1:1.67:3.33 were cast and tested after 7 and 28 d in order to have a comparative study. Workability is the relative ease with which concrete can be mixed, placed, compacted and finished. While, casting specimens, slump test were carried out to determine the workability of different samples as per IS: 6461-1973. Table 2 shows the variations of slump with water cement ratio for recycled concrete mixes. Cubical specimens were cast for the determination of compressive strength and these observations are presented as compressive strength values (Table 2, Fig. 1 and 2). Cubes up to 30% of coarse aggregate was replaced by demolished waste which gave strength closer to the strength of plain concrete cubes and strength retention was recorded in the range of 86.84-94.74% for recycled concrete mix.

Conclusion

The following conclusions are drawn from the experimental study.

1. Recycled aggregate concrete may be an alternative to the conventional concrete.
2. Water required producing the same workability increases with the increase in the percentage of demolished waste.
3. Up to 30% replacement of coarse aggregate with recycled aggregate concrete was comparable to conventional concrete.
4. Up to 30% of coarse aggregate replaced by demolished waste gave strength closer to the strength of plain concrete cubes and strength retention is in the range of 86.84-94.74% as compared to conventional concrete.

References

1. Collins, R.J. 1994. The use of recycled aggregates in concrete. BRE Report, Building Research Establishment, U.K. May.
2. Desmyster, J. and Vyncke, J. 2000. Proceedings of the 1st ETNRecy, net/RILEM workshop on use of recycled materials as aggregates in construction industry (posters). ETNRecy, net, Paris.
3. Dhir, R.K., Limbachiya, M.C. and Leelawat, T. 1999. Suitability of recycled concrete aggregate for use in BS 5328 designated mixes. Proc. of Civil Engg. Struct. Build. 134 (August), pp.257-274.
4. Hansen, T.C. 1992. Recycling of demolished concrete and masonry. RIELM Report No. 6, E and FN Spon, UK.
5. Hendricks, C.F. and Pieterson, H.S. 1998. Concrete: Durable but also sustainable. Proceedings of International Conference on the use of recycled concrete aggregates. Edited by Dhir, D.K., Henderson, N.A. and Limbachiya, M.C. Thomas Telford, U.K. pp.1-18.
6. IS:456-1978. Code of practice for plain and reinforced concrete. Indian Standard Institute, New Delhi.
7. IS:6461-1973. Properties of concrete, (part VIII), Indian Standard Institute, New Delhi.
8. IS:8112-1989. 43 Grade ordinary Portland cement, Indian Standard Institute, New Delhi.
9. Khalaf, F.M. and DeVenny, A.S. 2004. Performance of brick aggregate concrete at high temperatures, (ASCE), pp.899-1561.
10. Khatib, J.M. 2005. Properties of concrete incorporating fine recycled aggregate. *Cement Concrete Res.* 35: 763-769.
11. Mehta, P.K. and Monteiro, P.J.M. 1993. Concrete: Structures, properties and materials. New Jersey, Prentice Hall.
12. Padmini, A.K., Ramamurthy, K. and Matthews, M.S. 2002. Relative moisture movement through recycled aggregate concrete. *Cement Concrete Res.* 54(5): 377-384.
13. Ryu, J.S. 2002. An experimental study on the effect of recycled aggregate on concrete properties. *Magz. Concrete Res*. 54(1): 7-12.
14. Sherwood, P.T. 1995. Alternative materials in road construction. Thomas Telford, London.