Construction and Building Materials 167 (2018) 700–706

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Strength and permeation characteristics of cement mortar with Reclaimed Asphalt Pavement Aggregates

Sarah Mariam Abraham, G.D.R.N. Ransinchung *

Department of Civil Engineering, Indian Institute of Technology Roorkee, India

HIGHLIGHTS

- Gradation of aggregates affects strength parameters of RAP mortar.
- Contradicting behavior between porosity and sorptivity of RAP mortar.
- Conventional methodology to assess sorptivity does not cater to RAP mortar.

ARTICLE INFO

Article history:
Received 3 November 2017
Received in revised form 13 February 2018
Accepted 14 February 2018

Keywords:
Reclaimed Asphalt Pavement
Cement mortar
Strength
Sorptivity
Porosity

ABSTRACT

In order to assess the effect of fine fraction of Reclaimed Asphalt Pavement (RAP) aggregates as an alternative to natural fine aggregates (NA), cement mortar samples were prepared with 25%, 50%, 75% and 100% replacement of natural aggregates. The influence of grading of fine aggregates was also studied. Even though the compressive strength, flexural strength and splitting tensile strength were decreasing with increase in RAP content, the mortar mixes possessed minimum strength requirement providing the potential of fine RAP aggregate as an alternative. The trend of sorptivity characteristics of RAP cement mortar were in contradiction to the porosity nature of the same which suggests that the conventional methodology to determine the former will not cater for concrete or mortar mixes with RAP aggregates.

1. Introduction

With growing demand of construction materials, the extraction for the same, globally, has accelerated since early 2000's [1]. Environmental impacts due to procurement of natural aggregates causes ecological imbalance, deterioration of health, flora and fauna [2]. For the benefit of infrastructural development of any country, natural resources are being constantly utilized incognizance to environmental degradation it causes. As natural resources had been the primary source for aggregates in construction industry, the time has come for recycled aggregate to take that role. Economical and ecological benefits can be reaped from utilizing recycled aggregates thus making the construction sustainable. Construction and Demolition (C&D) waste, Reclaimed Asphalt Pavement (RAP) aggregate etc. are few sources of recycled aggregates. Almost 98% of pavements in India are flexible in nature [3,4]. Reconstruction and maintenance of such pavements generate RAP aggregates which can be reused in surface course of flexible pavements, base and subbases [5–9] as well as in concrete and mortar mixes [4,10–17,19–39]. RAP can be obtained through milling operation, pavement demolition or full depth reclamation [18]. The procurement of RAP aggregates is shown in Fig. 1.

India's Ministry of Road Transport and Highways is on the path of promoting rigid pavement construction for national highways. Several studies have been conducted for the use of coarse fraction of RAP aggregates in concrete but only few for fine fraction. In order to understand the effect of RAP fine aggregates as a replacement alternative, only a handful of studies have been conducted in cement mortar [19–21] rather than concrete, thereby its effect is not blinded by the action of coarse aggregate. The recycled aggregates received from the site may or may not fall in a particular grading zone. Studies related to the affect of gradation on mix properties were conducted on concrete with coarse RAP aggregates [24–26] and with fine RAP aggregates [24]. Berry et al. [24] relied on Response Surface Methodology (RSM) to determine the optimum replacement level of coarse and fine RAP aggregates and also to evaluate the effect of mixture parameters on concrete responses. With consideration to these factors, the objective of the study was

* Corresponding author.
E-mail addresses: sarah.dce2015@iitr.ac.in (S.M. Abraham), gdranfce@iitr.ac.in (G.D.R.N. Ransinchung).

https://doi.org/10.1016/j.conbuildmat.2018.02.075
0950-0618/

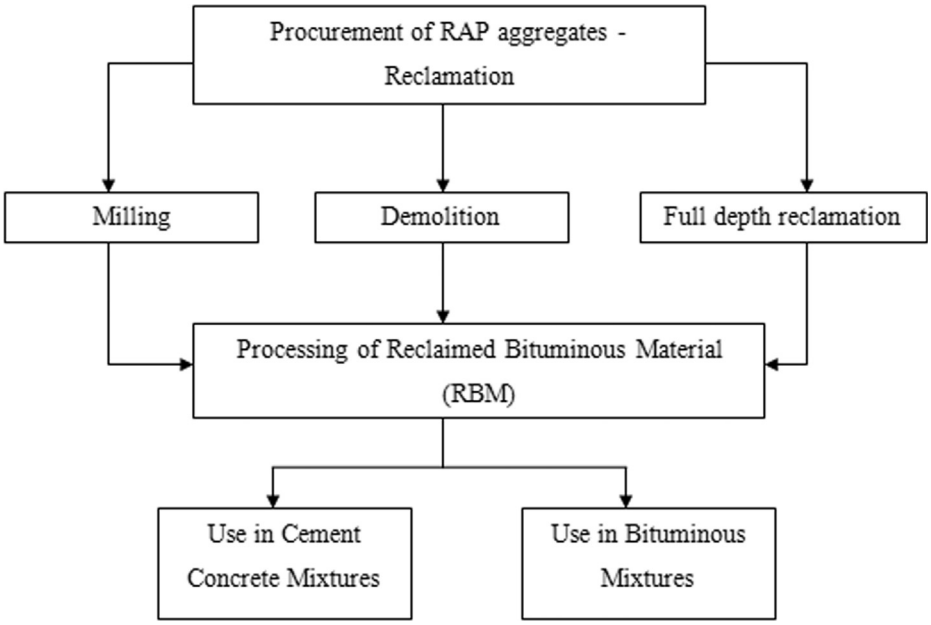

Fig. 1. Flowchart of production of RAP aggregates.

to analyze the effect of RAP as fine aggregate replacement to NA. For the reasons that the natural coarse aggregate may blind the effect of RAP fine aggregate, concrete and mortar possesses similar microstructures and smaller size test samples could be prepared because of the distribution of fine aggregates [40], cement mortar specimens were made rather than cement concrete with various part replacement levels of NA by RAP (25%, 50%, 75% and 100%). Separate mortar mixes were prepared with fine aggregate falling in a particular gradation zone (RAP mix) as well as Average Gradation Line (AGL) (line drawn through the average values of upper and lower limits of passing percentage of each designated Indian Standard (IS) sieve falling in the same grading zone) (R mix). Concrete specimens with various levels of RAP aggregate are studied later in the research program.

2. Experimental program

2.1. Materials

2.1.1. Cement

Ordinary Portland Cement of Grade 43 (OPC Grade 43) conforming to IS: 8112 [41] was used. The physical properties and chemical composition of the cement used are given in Tables 1 and 2 respectively. The chemical composition was determined by X-ray fluorescence spectrometry.

2.1.2. Fine aggregates

The fine aggregates used in this study were of two types viz, NA and RAP aggregates. The NA conformed to IS:383 [45]. RAP aggregates were obtained by pavement demolition of a flexible pavement (age more than 20 years) using a backhoe. The RAP aggregates consisted of a mixture of coarse aggregates (size > 4.75 mm) and fine aggregates (size < 4.75 mm). By proper sieving, the fine RAP aggregates were separated from the mixture. The present study utilized the same RAP and NA as in [22], hence they have the same parent rock i.e., sandstone. The particle size distribution and physical properties of NA and RAP aggregates are shown in Fig. 2 and Table 3 respectively. The bitumen content of RAP aggregates was determined using centrifuge extraction method in accordance with ASTM D2172 [46]. The chemical composition of NA and RAP aggregates determined through X-ray

Table 1
Physical Properties of Cement (OPC 43).

Property	Value	Reference
Consistency (%)	32	IS:4031 (Part 4) [42]
Initial setting time (min)	55	IS:4031 (Part 5) [43]
Final setting time (min)	311	IS:4031 (Part 5) [43]
Fineness (%)	5	IS:4031 (Part 1) [44]

Table 2
. Chemical composition of Cement (OPC 43).

Component	Amount (%)
SiO_2	16.230
Al_2O_3	3.987
Fe_2O_3	4.995
MgO	0.696
CaO	55.35
Na_2O	0.665
SO_3	3.910
K_2O	0.774

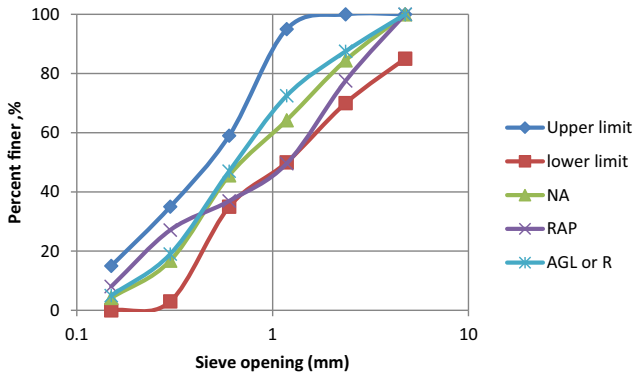

Fig. 2. Gradation of fine aggregates.