RESEARCH PAPER | Engineering | Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

Effect of Gradation of Fine Aggregate on Development of Hairline Cracks in Wall Plaster

KEYWORDS: cement plaster, hairline crack, gradation, fine aggregate

Dr. U. K. Das
Associate Professor, Dept. of Civil Engineering, Tezpur University, Tezpur, Assam,Pin 7840128

B. B. Bhardwaj
B. Tech. Student, Dept. of Civil Engineering, Tezpur University, Tezpur, Assam, Pin 7840128

B. Choudhury
B. Tech. Student, Dept. of Civil Engineering, Tezpur University, Tezpur, Assam, Pin 7840128

G. Sapkota
B. Tech. Student, Dept. of Civil Engineering, Tezpur University, Tezpur, Assam, Pin 7840128

ABSTRACT *Crazing or mapping are hairline cracks which develop in cement plaster surfaces exposed to long hours of sun. Shrinkage is the main factor for development of these cracks. The common causes attributed to shrinkage, and consequently hairline cracking, of plaster are rich cement content, higher water content, poor quality of fine aggregate, excessive quantity fines in aggregate, improper curing etc. In any plastering work the one variable which is highly location dependent is the quality of fine aggregate. A quantitative knowledge of the effect of quality of sand on development of hairline cracks will help the field engineers to adjust other variables like cement content etc. for better control of crazing. In this work a laboratory study on the effect of gradation of fine aggregate on crack development in plaster for different cement contents is carried out and the results and analyses are presented. The effect of inadequate curing is also studied in this work.*

INTRODUCTION

Formation of hairline cracks or crazing in external wall surface plaster is a common defect, particularly in walls exposed to long hours of sun. Crazing is a network of fine cracks, usually hexagonal in pattern, which measures between 5mm and 75mm across each hexagon. Craze cracks are usually very fine and shallow and may not extend through whole depth of plaster. Map cracking is similar to crazing except they are usually deeper and the hexagons of pattern may measure up to 200mm across.

Beer (2009) stated that map cracking can be caused due to plastic shrinkage of the plaster. Shrinkage cracks are the result of moisture loss after the plaster has hardened. Plaster will always shrink and crack, so it is desirable that it should develop a large number of fine, unnoticeable cracks at close spacing. Plaster with very high cement contents and those that are made of poor quality sands, having high water requirement, will tend to develop a few, widely spaced cracks. These cracks usually result from over-trowelling of rich mix or using sand containing excessive amount of dust.

Hall (1947) found shrinkage to be the chief factor in cracking of Portland cement plaster. Latta (1962) reported that Portland cement plaster can shrink more than one inch per hundred lineal feet due to seasonal temperature variations of the local climate. Richer cement content, improper curing, excessive fines content in aggregate were identified in one technical note as primary causes of crack development in cement plaster. Bowlsby (2010) stated that smaller cement plaster panel sizes may be used to reduce cracking.

In the literature studied, although it was generally accepted that aggregates having higher fines percentage requires more water for the same workability and hence develop more shrinkage cracks, quantitative data on the effect of size and grading of fine aggregates on development of hairline cracks in cement plaster could not be found. Since crazing in external wall plastered surfaces is quite often seen in buildings, this research work was taken up to study the effect of gradation of the fine aggregate in the development of hairline cracks in cement plaster.

In this work it is hypothesized that, if finer grade of sand is used in the mortar for plaster, hairline cracks will occur more readily due to development of higher pore suction in the plaster mortar than in the case where sand of coarser grade is used for preparing the mortar.

CASE STUDY

In the present study, effect of gradation of fine aggregate on development of hairline cracks in cement plaster was investigated. Samples of cement plaster were prepared over a flat base using fine aggregate belonging to different gradation zones. The samples were subjected to alternate drying in oven and cooling in atmospheric temperature until development of crack. Since the cracks were not easily identifiable to unaided eyes the development of cracks in these samples were carefully monitored by taking 30x magnified photographs of each sample. These macro photographs of the sample surface were taken every time a sample was taken out of the oven for cooling.

Sample Preparation

Plaster samples were prepared using mixture of Ordinary Portland Cement and Sand under the following different conditions:

1) Cement Sand proportion of 1:4, 1:6 and 1:8.

2) Using sand belonging to three different gradation zones of sand as specified in IS:383-1970.

Over trowelling was carefully avoided while preparing the samples. Grading of the sand collected from 3 different sources for this work were carried out and three different sand samples belonging to three different gradation zones of sand as specified in IS:383-1970 were arrived at. The particle size distribution curves of the three final graded sand samples (Sand A, Sand B and Sand C) are plotted in Figure 1. below.

Volume : 3 | Issue : 5 | May 2013 | ISSN - 2249-555X

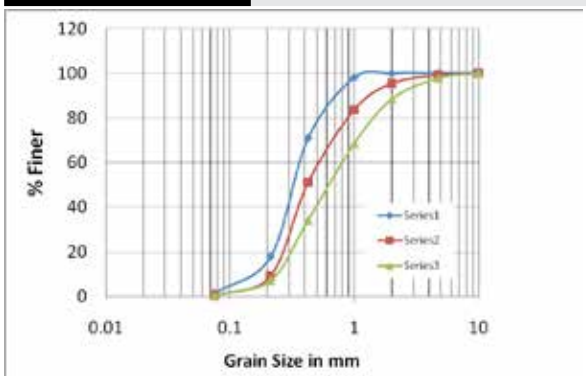

Figure 1: Particle size distribution curves of the sand samples, Sand A, Sand B and Sand C

Figure 1 above shows that Sand A, Sand B and Sand C fall in Zone IV, Zone III and Zone II grades of fine aggregate respectively as specified in IS:383-1970.

For each of the three grades of sand used in this study 3 samples were prepared for every cement-sand proportion keeping 10mm thickness of plaster. Out of the 3 samples prepared for every group, 2 samples were cured for 14 days and 1 sample was cured for 2 days. A total of 27 samples were prepared for this work.

EXPERIMENTATION

Each sample was kept in oven for 12 hours at a temperature of 80^{0}C. Although the maximum temperature to which the plaster is exposed to under natural condition is around 40^{0}C in Indian condition, the higher temperature in laboratory was adopted to expedite the process of crack development. In order to simulate field condition, after 12 hours of heating each sample was taken out of oven and allowed to cool in room temperature for 12 hours and then put back in oven for next 12 hours. This alternate heating and cooling is continued until noticeable crack was developed in the sample. During the cooling period each sample was cured with water. Every day after bringing the samples out of oven, each were carefully checked for any indication of development of crack with the help of macro photography. The number of days taken by a sample to develop crack was recorded.

EXPRIMENTAL RESULTS

For each of the three grades of sand used in this work the number of days required for development of crack in the samples having the same Cement Sand ratio and curing period of 14days were recorded during laboratory experiments and the average number of days required were determined. These results are shown in Figure 2 below as a plot of Number of Days required for crack development vs. Cement sand ratio (represented in terms of Volume of sand per unit volume of cement).

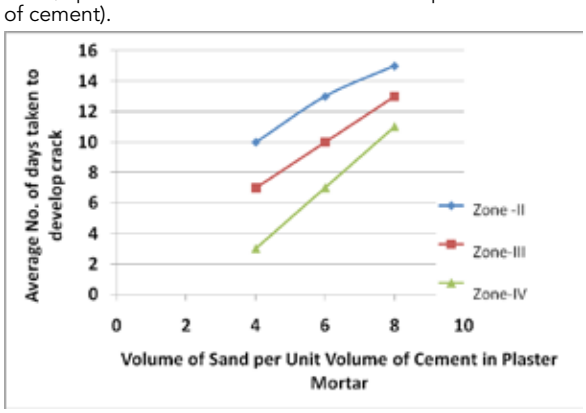

Figure 2 : No. of days taken to develop crack vs. Sand Cement Ratio of mortar for plaster cured for 14 days.

The number of days required for crack development in the plaster samples which were cured for 2 days against their respective cement Sand Ratio (represented in terms of Volume of sand per unit volume of cement)are shown in Figure 3 below.

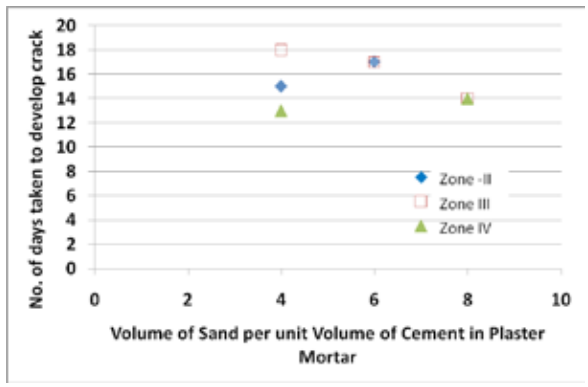

Figure 3: No. of days taken to develop crack vs. Sand Cement Ratio of mortar for plaster cured for 2 days.

INTERPRETATION

In the case of plaster samples which were cured for 14 days, it is observed from Figure 2 that:

1) As grade of sand used goes from finer (Zone IV) to coarser (Zone II) the average number of days required for crack development increases from 3 days to 10 days for 1:4 cement sand ratio, 7 days to 13 days for 1:6 ratio and 11 days to 15 days for 1:8 ratio.
2) The increase in the average No. of days taken for development of cracks from Zone IV to Zone II decreases from 7 days to 4 days as the cement sand ratio decreases from richer mix (1:4) to leaner mix(1:8).
3) The number of days to develop cracks increases almost linearly as the cement sand mix changes from richer to leaner mix.

In the case of sample which were cured for 2 days, it is observed from Figure 3 that the time taken for crack development for each cement sand ratio remain within the range from 13 to 18 days.

CONCLUSIONS

From the present study it is concluded that gradation of fine aggregate (sand) has definite effect on the occurrences of hairline cracks in cement plaster. The hairline cracks occur more readily for finer grade of sand than in the case of coarser grade of sand, the effect being more prominent in mortar with richer cement content. The possibility of development of hairline cracks linearly increases with the increase in richness of cement in the mortar used for plaster. In the case of plaster which is insufficiently cured, the effect of sand gradation on development of hairline cracks is not very significant. The findings of this study will have its use in controlling the development of hairline cracks in cement plaster.

REFERENCE [1]Beer, J. D. (2009), "Common defects in plaster." Cement and Concrete Institute, Midland. | [2] Bowlsby, J. (2010),"Cement plaster matrix:Quantifying Stucco shrinkage and other movements; Crack acceptability criteria for evaluating Stucco" Building Envelope Technology Symposium, 19-34. | [3]Bureau of Indian Standards Code of Practice(1970), "Coarse and Fine Aggregate form Natural Sources for Concrete." IS:383-1970. | [4]Hall, B.(1947), "Crack control in cement Portland cement plaster panels." Journal of American Concrete Institute, 44(10), 129-140. | [5]Latta, J. K.(1962), "Water and Building materials." Canadian Building Digest, CBD30. |