A proposed revision in national standards for limits on deleterious material (clay lumps) in fine and coarse aggregates

Dear Sir,

This has reference to the paper title 'A proposed revision in national standards for limits on deleterious material (clay lumps) in fine and coarse aggregates' by Rajesh S. Londhe and Chinmay V. Naik published in The Indian Concrete Journal, September 2014, Vol. 88, No. 9, pp. 46-50.

The above paper is on the use of natural river sand with the addition of clay lumps up to 5% on the strength properties of concrete. Authors have designed concrete for compressive strength of 40 MPa and tested 66 cubes at 7 and 28 days. Reduction in strength of concrete due to the addition of clay lumps from 1 to 5% at 1% increment is reported. The results are quite encouraging and the discusser congratulates the authors for their work. It is a simple laboratory testing on the strength properties of cubes. The discusser has the following points to be discussed from the point of clarification and better understating of the results.

1. Testing of cement: testing of cement should be as per IS 4031 (Parts 1-10) and not as per IS 12269:1987, which is only a specification code.

2. Fineness of cement: It should be preferably be determined in terms of Blaine's air permeability [1] and not based on percentage of fines passing 90 micron sieve as reported especially when the effect of fine clay is studied. Fineness found by sieving as no relevance in research.

3. Specific gravity of cement: It is mentioned as 3.15% (Table 2) as against 3.15. Such mistakes should be avoided in journals.

4. Fineness modulus: Maximum fineness modulus (FM) for coarse sand is generally in the range of 2.8-3.2. The value of 3.76 mentioned in Table 3 is very high. Authors are advised to check the calculations. For coarse aggregate, 20 mm and down size, FM is usually in the range of 6 to 7 with an average size of 6-7 mm based on the sieve size. Here the reported FM of 8.22 (Table 3) corresponds to an average size of 20 to 40 mm (size of 8^{th} to 9^{th} sieve from bottom). How can this be 20 mm and down aggregates? Authors are advised to check the calculation and to give the correct FM.

5. How clay lumps are collected and used in the investigation. What is the average size of clay particles in

the lumps used? Both size and amount of fines effect the reduction in strength of concrete. This may be clarified.

6. Compressive strength of concrete decreases as the percentage of lumps in aggregates increases. This is well documented in the literature. Authors also have observed this trend. However the reduction in strength observed by the authors is very high. Usually 3-5% of clay lumps whose size is comparable to or more than that of the aggregate size may not result in substantial strength reduction especially when the lumps are harder. In such case lumps affect the quality of concrete in the vicinity of lumps. If the lumps are broken in to powder and used as fines, then the reduction in strength is substantial. This should be addressed.

7. In sand, lumps larger than 1.18 mm are broken into finely divided particles with finger and sieved through 850 micron to determine the percentage of lumps. These broken lumps will decrease the strength significantly. If sand is used as it is with actual lumps, the strength may not decrease much. What is important in deleterious materials is the presence of particles finer than 75 micron. If these particles are reactive in nature, then the performance of concrete is questionable. Many of the properties of concrete namely rate of hydration, setting, performance of admixtures and durability related properties, etc will be affected, which is a matter of big concern which is to be addressed properly.

8. If concrete is produced by continuous agitation importing dynamic effect as in case of HPC or SCC or in today's RMC concrete, there is a possibility of all clay lumps broken in to fine particles which will further affect the performance of concrete. In such cases it is better to avoid lumps in aggregates.

9. In the present work authors have determined only he compressive strength of concrete. Attaining certain level of strength in concrete is not an issue for any concrete using any ingredients. If 5% of lumps can decrease the compressive strength of concrete by about 35% as reported, it can be make up to that of control concrete by decreasing the water cement ratio and by adding suitable dosage of admixture to get the required workability. This can be addressed by suitable mix design [2, 3]. What is important with deleterious materials is the performance of concrete as mentioned earlier which should be addressed.

10. As we all know, in future one need to use artificial aggregates (manufactured sand). The major deleterious materials in such aggregates is the presence of high amount of fines (<75 micron). This also can be handled with suitable mix design. Some time higher percent of fines is recommended in HP concretes. As these fines are from the same parent rock, in a way it is not deleterious if handled properly. Reactive minerals in fine form in any sand should be avoided in all concretes [4].

11. Authors in introduction state clearly that the deleterious materials are harmful as they react chemically with cement. Knowing this, the authors are recommending 3% of lumps in fine and coarse aggregates separately as against 1% suggested by IS:383 (draft on revision). The authors are defending this point in order to avoid the rejection of natural aggregates even if the lumps are about 3%. If somebody uses 3% of lumps in both fine and coarse aggregates, then totally it is 6% in addition to particles finer than 75 micron about with the authors are very salient. With this, reduction in strength will be enormous in addition to detrimental effects which are not addressed by the authors. In such situation it is better to avoid sand with higher percent of lumps and recommended to go for manufactured sand as it is becoming popular these days. Use of manufactured (or artificial) sand should be encouraged from the point of view of sustainability and related environmental issues as well [4].

12. In coarse aggregate, the sizes of lumps are generally larger (> 4.75 mm). 5% of lumps are like introducing 5% of light and weak material in to concrete. This may not decrease the compressive strength substantially if the lumps are not broken down to the level of cement during mixing and casting. Otherwise decreasing in compressive strength is substantial in addition of harmful effects if clay is reactive which should not be ignored.

13. Influence of clay lumps on workability of concrete is not reported. As the mix is designed, the target and the obtained workability and its variation due to addition of lumps should be discussed as it is one of the important

requirements in any concrete. Behavior of clay lumps in concrete with and without plasticizer will not be same and its influence on fresh and hardened properties will also be different. This point may be discussed in detail.

14. Most of the papers reported by the authors are on the use of clay as fine particles. In actual practice the clay will be in form of lumps in aggregates. The size of the clay particles and how these particles will be distrusted in the cement matrix and the related reactions should be studied based on the time and nature of mixing of concrete.

Concluding remarks

Discusser is of the opinion that any aggregates which satisfy the requirements of standards are good for making concrete. Even a slight deviation from the requirements can disqualify its use. With regard to deleterious materials one should be very careful as it leads to many serious problems. Any suggestion regarding proposed revisions to the standards should be based on continuous long terms studies by different national laboratories and related discussions in various engineering forums. Just some studies on compressive strength of concrete cannot support the facts. As most of today's and the future concrete will be with lots of minerals and chemicals, presence of reactive clay should be totally avoided. However the efforts of the authors should be appreciated.

References

1. IS 4031 (Part 2)-1999 (Reaffirmed 2004) Methods of physical tests for hydraulic cement, Part 2 Determination of fineness by Blain air permeability method, Bureau of Indian Standards, India, 2004.
2. Nataraja M. C, Lelin Das, "A simplified mix proportioning for cement based composites with crushed tile waste aggregate", Journal of Scientific and Industrial Research, India 2011, Vol. 70, No. 5, pp. 385-390.
3. Nataraja M. C, Nagaraj T. S, Bhavanishankar S, Ramalinga Reddy B. M. "Proportioning cement based composites with burnt coal cinder", Materials and Structures, 2006; Vol. 40, No. 6, pp. 543-552.
4. Nataraja M.C., Manu A.S, Girish, "Utilization of different types of manufactured sand as fine aggregate in cement mortar", The Indian Concrete Journal, Vol.88, No.1, 2014, pp. 19-25.

Dr. M. C. Nataraja,
Professor, Civil Engineering Department
Sri Jayachamarajendra College of Engineering
Mysore 570 006, India

THE AUTHORS REPLY

Dear Sir,

We are very much thankful to the discusser by suggesting and giving valuable suggestions in the paper. Our replies are as follows.

The paper is on the use of natural river sand with the addition of clay lumps up to 5% on the strength properties of concrete. Authors have designed concrete for compressive strength of 40 MPa and tested 66 cubes at 7 and 28 days. Reduction in strength of concrete due to the addition of clay lumps from 1 to 5% at 1% increment is reported. The results are quite encouraging and the discusser congratulates the authors for their work. It is a simple laboratory testing on the strength properties of cubes. The discusser has the following points to be discussed from the point of clarification and better understating of the results.

1. Testing of cement: testing of cement should be as per IS: 4031 (Parts 1-10) and not as per IS: 12269-1987, which is only a specification code.
Answer: The test procedure has been followed by guidelines as per IS: 4031. However the IS: 12269-1987 has been listed in references instead of IS: 4031.

2. Fineness of cement: It should be preferably be determined in terms of Blaine's air permeability [1] and not based on percentage of fines passing 90 micron sieve as reported especially when the effect of fine clay is studied. Fineness found by sieving as no relevance in research.
Answer: Here clay does not mean a mineral it should be read as clay lump. Hence there is no need to check fineness of cement with such apparatus as alternative test procedure has been suggested by IS: 4031 (Part 1).

3. Specific gravity of cement: It is mentioned as 3.15% (Table 2) as against 3.15. Such mistakes should be avoided in journals.
Answer: The value of specific gravity can be read as 3.15 instead of 3.15% shown in Table 2 of the paper.

4. Fineness modulus: Maximum fineness modulus (FM) for coarse sand is generally in the range of 2.8-3.2. The value of 3.76 mentioned in Table 3 is very high. Authors are advised to check the calculations. For coarse aggregate, 20mm and down size, FM is usually in the range of 6 to 7 with an average size of 6-7 mm based on the sieve size. Here the reported FM of 8.22 (Table 3) corresponds to an average size of 20 to 40 mm (size of 8^{th} to 9^{th} sieve from bottom). How can this be 20mm and down aggregates? Authors are advised to check the calculation and to give the correct FM.

Answer: The correction to fineness modulus of coarse aggregate as 7.08 should be made instead of 8.22 and shown in Table 3 of the paper. The sand has been washed several times and sun dried to remove the random percentage of clay lumps in fine aggregate and to make initial value of percentage of clay lumps in fine aggregate as zero. This may cause the removal of too fine particles and leads to coarser sand thus the fineness modulus seen to be increased.

5. How clay lumps are collected and used in the investigation. What is the average size of clay particles in the lumps used? Both size and amount of fines effect the reduction in strength of concrete. This may be clarified.

Answer: The clay lumps were collected from local farms. The clay lumps mainly composed of black cotton soil. The clay lumps were handled in such manner that they should not broken during sieving process. For checking the effect of clay lumps in coarse aggregate the clay lumps were sieved from 20 mm sieve and retained on 2.36 mm sieve as it is the sieve size specified by IS:2386 (Part 2) Cl. 2.4 for classifying the clay lumps and coarse aggregate. Also for checking the effect of clay lumps in fine aggregate the clay lumps are sieved from 4.75mm sieve and retained on 850 micron. Such sieve size has been chosen with reference to Cl. 2.4, IS: 2386 (Part 2) for classifying the clay lumps and fine aggregate.

6. Compressive strength of concrete decreases as the percentage of lumps in aggregates increases. This is well documented in the literature. Authors also have observed this trend. However the reduction in strength observed by the authors is very high. Usually 3-5% of clay lumps whose size is comparable to or more than that of the aggregate size may not result in substantial strength reduction especially when the lumps are harder. In such case lumps affect the quality of concrete in the vicinity of lumps. If the lumps are broken in to powder and used as fines, then the reduction in strength is substantial. This should be addressed.

Answer: Here the clay lumps used for experimentation are mainly of black cotton soil which is having ability to swell when comes in contact with water. So there were the chances of formation of large voids due to swelling and shrinking of soil of clay lumps resulting in decrease in the strength. Also in some cases it turns into powder form when comes in contact with water and such loose clay lump soil obviously decrease the strength. Authors have seen such trend of decrease with clay lumps composed of black cotton soil; however this percentage decrease in strength with inclusion of clay lumps in aggregate may vary from composition of clay lump's soil

7. In sand, lumps larger than 1.18 mm are broken into finely divided particles with finger and sieved through 850 micron to determine the percentage of lumps. These broken lumps will decrease the strength significantly. If sand is used as it is with actual lumps, the strength may not decrease much. What is important in deleterious materials is the presence of particles finer than 75 micron. If these particles are reactive in nature, then the performance of concrete is questionable. Many of the properties of concrete namely rate of hydration, setting, performance of admixtures and durability related properties, etc will be affected, which is a matter of big concern which is to be addressed properly.

Answer: This paper is aimed to focus the effect of clay lumps in aggregate on compressive strength of concrete. Authors have also checked the effect of 75 micron minus particles in fine aggregate on compressive strength of concrete in their research which is beyond scope of topic of present paper. However the nearby same trends of decrease in strength with increase in 75 micron minus particles in fine aggregate have been observed.

8. If concrete is produced by continuous agitation importing dynamic effect as in case of HPC or SCC or in today's RMC concrete, there is a possibility of all clay lumps broken in to fine particles which will further affect the performance of concrete. In such cases it is better to avoid lumps in aggregates.

Answer: Authors are thankful to reviewer for highlighting one of the possible causes of breaking clay lumps in modern high performance concrete. In this paper we have discussed the scope of using aggregates with certain percentage of clay lumps which are used for normal construction practices. Here the reduction in strength within certain percentage was considered to be acceptable in consideration with rejection and wastage of natural aggregates.

9. In the present work authors have determined only he compressive strength of concrete. Attaining certain level of strength in concrete is not an issue for any concrete using any ingredients. If 5% of lumps can decrease the compressive strength of concrete by about 35% as reported, it can be make up to that of control concrete by decreasing the water cement ratio and by adding suitable dosage of admixture to get the required workability. This can be addressed by suitable mix design [2, 3]. What is important with deleterious materials is the performance of concrete as mentioned earlier which should be addressed.

Answer: Here an attempt have been made to highlight the effects of using deleterious material (Clay lumps) in natural aggregate on compressive strength because all other mechanical properties can be derived from compressive strength. Moreover, compressive strength of concrete may be affected by changing (increasing/ decreasing) the water cement ratio and by adding suitable dosage of admixture, however, an attempt have been made to highlight the effects of using deleterious material (Clay lumps) in natural aggregate on compressive strength of concrete, which may be additional affecting parameter.

10. As we all know, in future one need to use artificial aggregates (manufactured sand). The major deleterious materials in such aggregates is the presence of high amount of fines (<75 micron). This also can be handled with suitable mix design. Some time higher percent of fines is recommended in HP concretes. As these fines are from the same parent rock, in a way it is not deleterious if handled properly. Reactive minerals in fine form in any sand should be avoided in all concretes [4].

Answer: Yes this is truth in the future, but some experimental work from all parts of the country from academicians, scientists etc are necessary.

11. Authors in introduction state clearly that the deleterious materials are harmful as they react chemically with cement. Knowing this, the authors are recommending 3% of lumps in fine and coarse aggregates separately as against 1% suggested by IS:383 (draft on revision). The authors are defending this point in order to avoid the rejection of natural aggregates even if the lumps are about 3%. If somebody uses 3% of lumps in both fine and coarse aggregates, then totally it is 6% in addition to particles finer than 75 micron about with the authors are very salient. With this, reduction in strength will be enormous in addition to detrimental effects which are not addressed by the authors. In such situation it is better to avoid sand with higher percent of lumps and recommended to go for manufactured sand as it is becoming popular these days. Use of manufactured (or artificial) sand should be encouraged from the point of view of sustainability and related environmental issues as well [4].

Answer: Here it should be clearly understood that these revised limitations are meant for individual presence of clay lumps in either fine or coarse aggregate and not meant for both revised percentage at a time.

12. In coarse aggregate, the sizes of lumps are generally larger (> 4.75 mm). 5% of lumps are like introducing 5% of light and weak material in to concrete. This may not decrease the compressive strength substantially if the lumps are not broken down to the level of cement during mixing and casting. Otherwise decreasing in compressive strength is substantial in addition of harmful effects if clay is reactive which should not be ignored.

Answer: Authors are agree with the discusser's opinion.

13. Influence of clay lumps on workability of concrete is not reported. As the mix is designed, the target and the obtained workability and its variation due to addition of lumps should be discussed as it is one of the important requirements in any concrete. Behavior of clay lumps in concrete with and without plasticizer will not be same and its influence on fresh and hardened properties will also be different. This point may be discussed in detail.

Answer: The slump loss increases as the percentage of clay lumps in fine and coarse aggregate increases. The substantial slump loss has been seen in case of clay lumps in fine aggregate as compared to clay lumps in coarse aggregate. Use of admixtures can control this parameter

without affecting the strength of concrete. This study can also be continued in aspect of use of different dosage of admixtures for a fixed percentage of clay lumps in aggregate without nullify the effect of clay lumps on strength, as the clay lumps absorb the water during mixing and leads to less workable hence low strength concrete.

14. Most of the papers reported by the authors are on the use of clay as fine particles. In actual practice the clay will be in form of lumps in aggregates. The size of the clay particles and how these particles will be distrusted in the cement matrix and the related reactions should be studied based on the time and nature of mixing of concrete.

Answer: Due to time limitations, other study had not been carried out; however, the study as suggested may be carried out in future. We are very much thankful to the discusser by suggesting a very good suggestion, which may be addressed in future.

Concluding remarks

Discusser has studied all the contents of the paper, which normally, nobody does, may be because of lack of time and or some limitations. It is very necessary to have such discusser so that the proper corrections shall be pointed out and quality of the paper can be improved. We personally, appreciate the efforts taken by the discusser to give the suggestions.

Further, the authors are ready to provide any more clarifications about the contents, if needed.

Dr. R.S. Londhe
Associate Professor of Applied Mechanics,
Maharastra Government Engineering College Teaching Services, Class-I, Government College of Engineering, Aurangabad 431 005, Maharashtra, India.