

**WORKSHOP ON AGGREGATES –
FLAKINESS AND ELONGATION INDICES
(WSOA-2006)
13th June 2006 (Tuesday)
At CRRI, New Delhi**

Inaugural Session

Dr. P.K. Nanda, Director, CRRI, delivered the welcome address stating about the absence of MoSRTTH and NHAI officials due to emergent meeting called by the Transport Minister (MoSRTTH) at Trichi. He emphasized on material conservation and suggested that there is an urgent need to think on demand and supply system with respect to environmental equilibrium. The pavement design procedure should be reviewed to save precious natural resources. In older practice, the initial cost was considered, later on the cost of construction and maintenance were considered and lastly the concept of life cycle cost consideration was introduced.

Dr. B.P. Chandrashekhar, Director (Technical), NRRDA, Guest of Honour, shared his experiences and stated that the shape and size of aggregates change drastically during compaction. Minimizing the voids should be tried and more emphasis should be given for locally available materials. The deliberations and discussions will bring out useful results for highway profession.

Prof. V.S. Raju, Chairman of the session, deliberated upon Indian specifications and emphasized that these should be close to reality and neither under nor over-specified. These should also be easily achievable without compromising the quality of construction. He said that it was right time to update the Indian codes and Information Technology related to these codes. CRRI should be involved for training Human Resources. CRRI is the organization to come forward to provide R&D inputs for revision of codes.

The session ended with Vote of Thanks by Sh. Satander Kumar, Scientist, CRRI and Organising Secretary of the workshop.

Technical Session I

Session I dealt with “Flakiness Index (FI) and Elongation Index (EI) of Aggregates – National and International Practices”. The session was chaired by Dr. S.K. Rao of M/s.Lee Associates and co-chaired by Sh. S.A. Reddi (M/s Gammon India Ltd.) and Sh. R.K. Jain (Retd. CE of Haryana PWD).

Dr. Rao stated that Indian specifications for Flakiness Index (FI) and Elongation index (EI) seem to be over-specified. There is a need to review the present equipment for arriving at FI and EI. Superpave mix design uses different types of gauges to find out the FI and EI as per American specifications and demonstrated it with a simple apparatus (gauge). He gave a brief description of American procedures to estimate FI and EI of aggregates.

Sh. S.A. Reddi gave a presentation on pragmatic requirements for FI and EI. He delivered an exhaustive review on national and international codes and compared their limits. A brief description was also given by him about various types of crushers used in the production of right type of aggregates. He emphasized that CRRI should validate Euro/American specifications for the revision of Indian specifications and recommending the same to MoSRTTH. He also presented that only FI value need to be considered for design and he gave interim suggestions for FI based on his experience. He concluded that CRRI is the right organization to evaluate and come forward with definite recommendations to MoSRTTH.

Sh. R.K. Jain stated that the limits of combined FI and EI ranging from 25% to 60% have marginal effect on basic properties of mixes but these are within the limits.

Mrs. Binu Mathew, Lecturer of Civil Engineering, College of Engineering, Thiruvananthapuram, presented her work based on four different combinations of FI and EI related to bituminous mixes to select the best ratio between the two. The study concludes that there is less variations in the properties of bituminous mixes when values of FI and EI percentages are equal.

Dr. M.I. Anjum, Gosia College of Engineering, Karnataka, gave presentation on effects of shape factor and gradation of aggregates on various properties of bituminous mixes. He concluded that the variation in combined Indices from 30 to 40% does not have much effect on the properties of mixes. He showed at length, the gauge developed at Gosia College of Engg. Karnataka, for FI & EI measurements of aggregates.

Dr. Animesh Das of IIT, Kanpur, presented his talk on “Use of Digital Image Processing (DIP) Techniques for Determination of Shape Factors of Aggregates”. The technique is less time consuming with no subjective judgement and having statistical reliability. The technique is very good for assessing the size and shape of aggregates even before and after the rolling of bituminous mixes. The drawback of the technique is that it does not give the volume of aggregates due to two dimensional picture.

Dr. L.R. Kadiyali of M/s. L R Kadiyali & Associates, New Delhi, commented on deliberations made during workshop on FI and EI stating that flaky aggregates consume more asphalt rather than non flaky aggregates which is important in estimating cost factor. **The value of 35% combined indices of aggregates adopted in 1995 MoSRTTH specifications was totally based on experience and is required to be validated.**

Dr. N.C. Shah, Prof. in Civil Engg. SVNIT, Surat stated that combined indices value depends on the type of rock. He gave an example of a case study in

which the hard rock having FI upto 50% gave good results in performance whereas soft rock with proper specifications had low performance. He Stated that the results are doctored where values in the field go beyond the specifications. Obviously specifications required upward revision of values of Flakiness Index.

Dr. Sunil Bose, Head, FP Div. CRRI presented findings of studies on FI of aggregates in bituminous mixes. He presented results of tests carried out on dense bituminous mixes. **The laboratory performance characteristics of bituminous concrete mixes indicated marginal variation when the combined indices of the aggregates used in the study ranged from 25 % to 35%. He concluded that the limiting value of combined indices should be based upon category of roads.**

Mr. Satander Kumar, Scientist, RPD, CRRI, presented the results of laboratory studies conducted on aggregates (FI varying from 0 - 100%) in concrete pavements. He concluded that FI upto 40% will not have any adverse effect in concrete mixes for highways and other structures .

Sh. Y.R. Phull, Retd. Senior Scientist of CRRI, presented an exhaustive quality control method for aggregates and its properties for concrete pavements.

At the end of the session, Sh S.A. Reddi, summarized the session proceedings stating that India has signed WTO agreement and, therefore, has to harmonize the codes and specifications with Euro Codes which allow upto 50% Flakiness Index (FI) for concrete pavements . The economics and overall performance needs to be taken into consideration. Obsolete codes should be revised accordingly.

Technical Session II

Session II dealt with “Experiences on Crushers and other Equipments”. The session was chaired by Sh. D.P. Gupta, Ex-DGRD, MoSRTTH and Co-chaired by Sh. B.P. Kukreti, CGM, NHAI and Sh. V.K. Mehrotra, CE, MCD, Delhi.

Mr. Rajeev Gauri, Reliance Industries Ltd., New Delhi, presented the effect of Recron 3S fibre to control segregation of aggregates in concrete mixes and their bonding behaviour. He also deliberated on the shape of fibres specifically of triangular shape.

Sh. R.K. Jain, Retd. CE, Haryana PWD, presented on “Critical Need for the Revision of Existing Specification on Aggregates”. He presented the findings of two case studies. One on plain terrain i.e. Delhi-Mathura Road (NH2) and other on hilly terrain which is Kohima By pass (NH-39). He concluded that use of sub-standard aggregates based on present code performed well and upto the expectation. He recommended Flakiness Index of 40% for village roads and 35% for highways.

Sh. U.K. Guru Vittal, Sci, CRRI, presented on some recommendations for modification in “Aggregate Shapes Tests and Specifications”. He gave brief on various standards and their shortcomings and suggested for adopting the latest Euro code which is published in year 2004 and is use in UK.

Sh. M.V.B. Rao, Ex. Senior Scientist, CRRI, and Technical Advisor, IRC, presented his views on “Aggregates and Crushers”. He emphasized more on the type of crusher to be used with respect to type of rock.

Dr. Prakash Mehta of Zydex Industries, New Delhi, stated that the bond between bitumen and aggregates plays an important role. This can be improved by silane chemistry which has been existing for the last 30 years in

other countries, at a nominal cost. Silane chemistry modifies the hydroxyl group into hydrophobic group and creates good bonding.

The proceedings of the session was summed up by the co-chairman, Mr. B.P. Kukreti, (C. G.M., NHAI) with a view that optional limits/variation be allowed to field engineers because of non-availability/exorbitant cost of aggregates. It is right time to review specification and decide the relaxation given on this aspect.

Technical Session III

Following were the panelists for the session:

1. Sh.R.S. Sharma (Chairman), Secretary General, IRC
2. Sh. S.C. Sharma, ex-DGRD, MoSRTTH
3. Sh. D.P. Gupta, Ex. DGRD, MoSRTTH
4. Sh. K.B. Chander Shekhar, Director,NAC, Hyderabad
5. Sh. R.K. Jain, Retired Chief Engineer, Haryana PWD
6. Sh. B.P. Kukreti, GM, NHAI
7. Sh. V. Velayutham, ADG, MoSRTTH
8. Dr. P.K. Nanda, Director, CRRI

Sh. R.S. Sharma, Secretary General, IRC gave a brief description of limits of Flakiness/Elongation and combined indices, as the case may be, given in various codes/standards. **He emphasized that values of indices should be based on road type/category. He was of the opinion that crusher technology to be adopted such as jaw crusher or impact/VSI crushers is required to be looked into as it has cost implications. The method for determination of indices is also required to be reviewed. The MoSRTTH specifications 2001 are already under revision in IRC.**

Sh. S.C. Sharma, Retd. DGRD, MoSRTTH, stated that the shape factors affect the performance of roads. In India, it is limited to FI & EI only. In general, the value of FI & EI shall not be uniform for all the pavement layers. It shall be different for the pavement layers as well as it will depend upon traffic and category of the road. R&D inputs, based on field trials vis-à-vis lab data is urgently required to modify the limit specifications in Indian context. He was of the opinion that angularity with texture should be considered along with the indices. There is a need to review the reason for clubbing the FI & EI together. Total rationality of the whole process is to be worked out before giving any values to the highway profession.

Sh. D.P. Gupta, ex-DGRD, MoSRTTH pointed out that availability of aggregates is a big concern. There are bottlenecks to get right quality of aggregates for use in surfacing as per the design requirements. The road construction agencies should be encouraged to use softer aggregates in bottom layers with or without stabilization.

Sh. K.B. Chander Shekhar, Director, NAC, Hyderabad, emphasized that the use of locally available materials in highway construction shall be promoted to cut down the cost of construction. The combined value of FI & EI shall be relaxed, based on lab studies done so far in the country. The use of new technology "Digital Image Processing" should be used for determination of FI & EI, rather than by conventional method. There is an urgent need to do R&D on the present crushing technology.

Sh. R.K. Jain, Retd. Chief Engineer, Haryana PWD, strongly advocated the need for a study to ascertain as to why a jaw crusher produces the flaky aggregates. Use of marginal aggregates (near to the specified values) should be encouraged for lower layers. There is a need for study "Performance Evaluation of Roads" (depending upon the size and shape of aggregates) under actual field conditions, before suggesting any modifications in the

present combined value of FI and EI. Use of fibres/chemicals to improve the mix properties should be propagated for better results.

Sh. B.P. Kukreti, C.G.M., NHAI, was of the opinion that there is a need to modify the combined indices values. The combined indices value should not be the same throughout the country. The country should be divided in zones based on hardness of rocks. The value should be based on category of road/layer in which aggregates are to be used. A comprehensive study based on an actual field performance/study should be conducted before suggesting any value to highway profession.

Sh. V. Velayutham, ADG, MbSRTH stated that R&D efforts are required to find out way to produce right quality materials. A relaxation in combined indices values specially for lower layers may be thought of. Thorough studies are required to suggest values of combined indices for high/low volume roads.

Dr. P.K. Nanda, Director, CRRI agreed with the views of the panelists that the combined indices value shall be different for different layers. It should also be based on traffic volume on the road. The conventional jaw crushers produce flaky materials, whereas high technology crushers (core/impact type) produce more dust (about 40 per cent) which will cause environmental problems. He gave the brief of one report in which all basic properties of mix are meeting except combined indices. The lab study shows that there is no effect on concrete mix properties by varying combined indices even up to 50 per cent, hence there is an urgent need to optimize the value of combined indices under Indian context.

After the views of panelists, the floor was opened for general discussions. Sh. O.P. Gupta, Retd. Chief Engineer, MCD, Mr. Neil Boniface, Shri Guru Vittal, Sci, CRRI, Mr. Rakesh Kumar and others participated in the discussions. Finally the workshop was ended with a vote to thanks by Sh.Satander Kumar, Organising Secretary.

Recommendations of Workshop

The following are the major recommendations emerging from the workshop :

1. There are enough laboratory studies, which show that with the variation in Flakiness Index values from 35 to 50%, there is a change in the mix properties of cement concrete mixes. Similarly, with the variation in Flakiness Index values from 15 to 30%, there is a change in the mix properties of bituminous mixes. Observed variations in mix properties are within the permissible range for Flakiness Index values upto 30 and 50% in case of bituminous and cement concrete mixes respectively .
2. Detailed R& D is required to assess the effects of Flakiness Index values beyond 35% in actual field conditions .
3. There is a need for optimization of crushing technology i.e. selection of type of crushers, depending upon the geology of rocks to be crushed.
4. **There is urgent need to change the specifications for the Flakiness Index value of coarse aggregates. The Flakiness Index value should be based on type of layer, type of road, traffic volume , etc in order to make use of locally available material and also to minimize cost.**
5. **Use of present flaky & elongation indices gauge should be reviewed.** Gauge system working on the principle of maximum to minimum size say 2:1 or 5:1 may be used in the Indian context. Use of Digital Image processing techniques is to be explored in detail.

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