

# Influence of Fine Aggregate Gradation on Cement Mortar Properties

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**ABSTRACT:** In civil engineering construction river sand is used as fine aggregate for preparing cement mortar but due to the lack of availability of river sand nowadays M-Sand is introduced as fine aggregate. The voids present in cement mortar reduces its strength which may lead to crack formation. To reduce the voids present in the mortar, aggregate gradation is done to improve its strength and minimizes the requirement of binder particles in mortar. In this study 4.75mm, 2.36mm, 1.18mm, 90 $\mu$  of fine aggregate were used. Here the aggregate is sieved and cubes were prepared for different combinations of fine aggregate sizes and cubes of different combination of M-Sand casted for the mix proportion of 1:3. Then the cubes are allowed for curing. The strength of cubes were tested after 7 and 28 days curing. The maximum strength is attained by the cubes having mortar formed by the combined gradation of fine aggregates of 4.75mm, 1.18mm and 90 $\mu$ . The mortar cubes result justifies that proper grading of aggregates gives better result than the individual size of aggregate.

**KEYWORDS:** M-Sand, voids, gradation, strength, construction, mortar, cube, aggregate, combination

## I. INTRODUCTION

The study of fine aggregate gradation in mortar are comparatively very less when compared with the aggregate gradation in concrete. This study deals with the problems in the strength occurred in hardened mortar due to the lack of binders in the total volume of mortar. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate called gradation. This method is used primarily to determine the grading of materials proposed for use as aggregate or being used as aggregate. Due to the lack of awareness on aggregate gradation in cement mortar, it had some defects after hardening. The strength and formation of cracks, etc. are some of the defects possibly formed after hardening. Gradation of the aggregate is widely done in concrete, but it is not widely introduced in the cement mortar. Here in the cement mortar we have replaced the M-Sand as fine aggregate. Due to the poor quality and the cost increase and some other reasons M-Sand use is widely increased. The quality of M-sand is good and workability of mortar, is maintained by varying the water cement ratio in the mortar. M-sand sand is produced by introducing the broken aggregates into the crushers and washing them to remove the finer particles present in it.

Washing is done by us in the sieve before it used in mortar, washing removes the dust particles in the M-Sand. The water is pored through the sieve show that the finer particles than sieve size can easily pass through it and then original size of the fine aggregate particles can be easily taken from the sieve. There is no chance for the possibilities of presence other sizes of fine aggregate. The individual size of fine aggregate was being retained in each sieve.

Mortar is a homogenous material formed by the combination of cement, fine aggregate (River sand or any other artificial fine aggregates such as M-Sand, pond ash, etc.) and water. The cement mortar is mainly used in construction structures for various types of masonry works and it is also used for plastering the various kinds of masonry. Due to improper curing cracks were formed in the plastering work voids between the two particles may be also leads to crack in the structure. This is the major cause in the cement mortar.

The study of past literatures was also shows that the gradation of fine aggregate study is not widely done in cement mortar. Study on complete and partial replacement of fine aggregate with different artificial aggregates were able to known in the literature study, but there seems no wide presence of fine aggregate gradation in cement mortar.

## II. MATERIALS

Here we use Portland pozzolana cement (PPC) for the casting of mortar. The cement having the normal consistency of 34% and setting time of 30 mins and 200 mins as initial and final setting time respectively. In this study M-Sand is introduced as fine aggregate instead of normal river sand which is one of the artificial fine aggregate obtained from the crushers. The gradation of fine aggregate was an important parameter which plays a vital role in the compressive strength of the mortar. Water having the normal PH value required for drinking is used. M-Sand is sieved and the size of 4.75mm, 2.36mm, 1.18mm and 90 $\mu$  were taken for this study of gradation of fine aggregate in cement mortar. Properties of PPC 43 grade was shown in Table 1. The physical properties of M-Sand is listed in Table 2.

**Table 1. Properties of PPC 43 grade cement**

S. No	Physical Characteristics	Requirement as per IS 8812:2013	Test Results
1	Fineness Modulus, $m^2/kg$ , Min	225	240
2	Specific Gravity	3.17	-
3	Setting Time a) Initial b) Final	30 600	75 240
4	Standard consistency	34	-
The above cement complies with the requirements of IS8812:2013			

This table verify that these M-Sand is suitable for the fine aggregate in construction site. M-Sand is the highly used artificial fine aggregate in the modern construction. M-Sand properties were slightly changing when it is compared with river sand

**Table 2. Physical properties of M-Sand**

S.NO	DESCRIPTION	RESULT
1	Specific Gravity	2.68
2	Fineness modulus	2.64
3	Bulk Density	1755 $kg/m^3$
4	Water Absorption	1.2%

## III. METHODOLOGY

Firstly, M-Sand is sieved washing is done in the sieve to remove the finer particles in the sieve. Then aggregates were taken for mixing of 1:3 mix ratio. The demoulded cubes were cured for period of 7 and 28 days. The compressive strength of the cubes are tested after curing the cubes of improper sizes were not tested. The cubes were kept outside after the curing period for drying. Using the Compressive Testing Machine (CTM) the compressive strength of cubes were determined by loading it.

## IV. EXPERIMENTAL SETUP

In these experiment the M-Sand is taken from the certified crusher industry and then the physical properties of the crusher fines were studied to verify whether the physical properties were suitable for the replacement of fine aggregate in the

mortar. The water cement ratio is not defined it varies from one place to another based on the workability requirement. For initial mixing of mortar the water cement ratio is fixed as 0.4. Mix ratio of mortar is 1:3.



**Fig 4.2 Casted Cubes**

The cubes are prepared for individual size grading first and then the combination size aggregate with proper proportion was also moulded. The mould of 50mmX50mmX50mm were casted after proper mixing the demoulded cubes were in the curing period of 7 and 28 days. The moulded cubes were shown in fig 4.1. Then the cubes were tested using CTM is shown in fig.4.2.



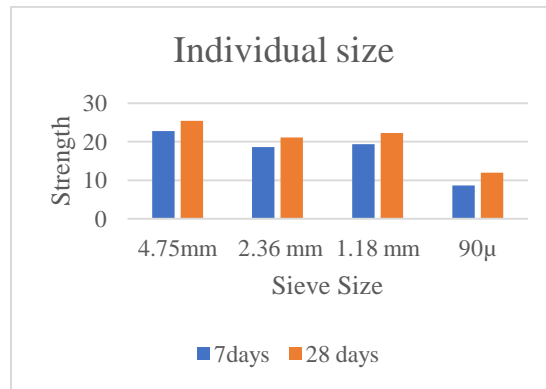
**Fig 4.2 Cubes in UTM**

Combinations	Sieve sizes
C-1	4.75mm+2.36mm+1.18mm
C-2	1.18mm+2.36mm+90 $\mu$
C-3	4.75mm+2.36mm+1.18mm
C-4	4.75mm+1.18mm+90 $\mu$

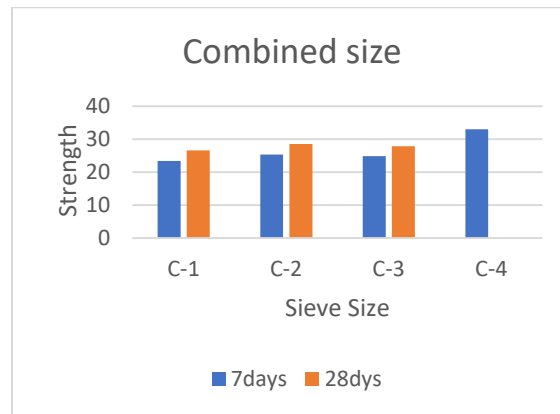
**Table 4.1 Combinations size**

**V. RESULT AND DISCUSSION**

The mortarcubes having the uneven shape is not taken for testing. The compressive strength of the mortar cubes having the individual and combined size of the fine aggregates were tested using the compressive testing machine after the curing period of 7 and 28 days. The bar-chart is prepared for the load and the graded fine aggregate. The combination and individual size strength were shown in the charts of Fig4.1 and Fig4.2

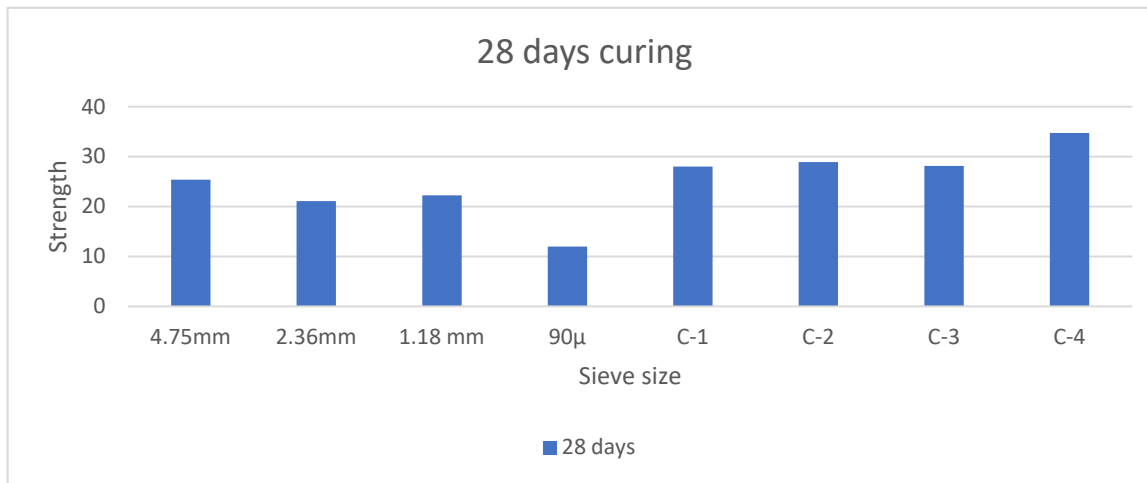


**Fig5.1 Bar-chart for strength of individual size**



**Fig 5.2 Bar-chart for strength of combined size**

The bar-chart shows that the minimum stress is observed by the 90 microns cube whereas the major stress is developed in the cubes formed by combination on graded aggregates of sizes 4.75mm,1.18mm& 90 microns which is denoted as C-4 in the chart. Thus CM1:3 formed by one part of cement with one part of 4.75mm fine aggregate, one part of 1.18mm fine aggregate & one part of 90 microns graded aggregates will have the higher strength with less amount of void formation with the same proportion mix adopted in the mortar is gained. The strength of mortar after 28 days curing is shown in Fig4.3



**Fig 5.3 Bar-Chart based on strength of 28 days curing.**

This study also states that the C-4 had also gives better strength when it is compared with the M-Sand which is not introducing the gradation of fine aggregate. This result had also states that combined graded fine aggregate forms better binding than the individual size aggregates. Aggregate gradation reduces the voids and produce better binding between the particles and gives better strength for masonry and plastering mortars by without changing the mix proportion of materials but it can be achieved only by applying the gradation of fine aggregate. By introducing gradation of aggregate the voids percentage in the cube is reduced and it also confirms that the formation of crack in the mortar is less due to proper bonding between the cement and fine aggregate.

## VI. CONCLUSION

In this study, the composite strength of cement by using the aggregate gradation is investigated. In cement M-sand from the crushers were used for alternatives FA aggregation. To improve its strength the FA is graded individually and combination.

The M-sand without grading is constant in strength where as individual grades is less while introducing the combination in aggregate grading the mortar strength is improved. These state that FA gradation gives better bonding by reducing the voids. The study shows the graded FA were occupying the gaps forms between the two particles in the mortar so that the percentage of voids is very less. The aggregation gradation results better experience in its strength. The formation of cracks is also less while the FA gradation.

## REFERENCES

- 1) Radhakrishna, Praveen Kumar K, "characteristics of cement mortar with M-Sand as replacement of fine aggregates", IConAMMA 2017, Proceedings 5 (2018) 25412–25419.
- 2) B V Venkataramareddy, "Suitability of manufactured sand as fine aggregate in mortars and concrete", Seminar document on Alternatives to river sand-A sustainable approach, Karnataka State pollution control board, Bengaluru, Karnataka, India, (2013).
- 3) Sureshbabu N, Job Thomas, "Bond characteristics of rebar in concrete with manufactured sand as fine aggregate", American Journal of Engineering Research (AJER), Vol 1 (2013)54-58
- 4) D. Cook, A. Ghaeezadeh, T. Ley, Investigation of Optimized Graded Concrete for Oklahoma vol. 11, OTCREOS, 2013, pp. 1–39
- 5) Mills Jeff C, Ioannides Anastasios M. Laboratory study of larger sized aggregate in Portland cement concrete. Int J Pavement Eng 2007;8(4):253–63
- 6) Crouch LK, Pitt Jordan, Hewitt Ryan. Aggregate effects on pervious Portland cement concrete static modulus of elasticity. J Mater Civil Eng 2007;19(7):561–8 [P.E.1].
- 7) Fan Yu, Daquan sun. "Influence of aggregate size on compressive strength of pervious concrete" 0950-0618(2019).



- 8) ASTM C 952-91. Standard test method for bond strength of mortar to masonry units. American Society for Testing and Materials; 1991.
- 9) I.S. 8112. Indian standard specification for 43 grade ordinary Portland cement. New Delhi, India: Bureau of Indian Standards; 1989.
- 10) Fitzmaurice R. Manual on stabilized soil construction for housing. New York: United Nations; 1958.
- 10) U.N. Report. Soil-cement – its use in building. New York, USA: Department of Economic and Social Affairs, United Nations; 1964.
- 11) Theunissen Ph. Building with earth Dimension 3. Bimonthly Rev Inform Serv Belgian Admin Dev Cooper 1985; 4:10–2.
- 12) Jagdish KS. The progress of stabilised soil construction in India. In: Proceedings of the National seminar on stabilised mud blocks for housing and building, vol. 1; 1988. p. 17–43.