

# Investigation on Fly Ash-Lime-Gypsum Mix Mixed with Stone Dust

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**Abstract:** Stone Quarry dust is a kind of solid waste material that is generated from stone crushing site which is abundantly available. It is estimated that there are over 12000 stone crusher units in India (Central Pollution Control Board Parivesh Bhawan East Arjun Nagar, Shahdara Delhi). Disposal of such wastes poses lots of environmental problems such as air pollution, health and environmental hazards. The best way to eliminate these problems is to make use of such waste. The research aims to utilize the bye-products of stone quarries i.e. stone dust and thermal power plants i.e. fly-ash by investigating their basic properties when combined together which can help to enhance the strength of composite materials. Keeping this in view an experimental study was conducted on locally available stone dust by mixing it with fly ash-lime-gypsum mix. The compressive strength of composite of fly ash-lime-gypsum-stone dust was found to increase after Burlap method of curing.

**Keywords:** OMC, MDD, UCS, Stone Dust

## 1. Introduction

In the present scenario, with the increase in the facilities and modernization the by-products of different activities are required to be used in such a way that they can be used to the best of their potential. The construction industry can start being aware of and take advantage of the benefits of using waste and recycled materials. Stone dust and fly ash are examples of such bye-products produced in large quantities from stone quarries and thermal power plants. The disposal of such waste materials is of great concern. The best method to dispose of the products is use them to make composite materials along with other basic construction materials which can be applied in various ways in construction of different types of infrastructure. The essential properties of such composite materials need to be investigated first so that their applications can be defined later. Experimental studies have to be carried out by combining fly ash, lime and gypsum together, which are necessary elements of construction materials due to their good properties, and adding quarry dust to the composite to study its effect on the overall properties of the mix. **Kumar Siva and Prakash (2011)** experimentally showed that the addition of quarry dust for a fine to coarse aggregate ratio of 0.6 was found to enhance the compressive properties as well as elastic modulus. **Sivapullaiah and Moghal (2011)** have reported that strength of fly ash, lime mix increases only up to the addition of optimum lime content as higher content beyond the optimum may have deleterious effect. Further experimental investigations on fly ash-lime-gypsum-stone dust have been studied in this research to use the waste product along with other materials.

## 2. Literature Review

Very little information has been published on the unconfined compressive strength of various materials mixed with quarry dust. However, various studies have been conducted regarding use of quarry dust to improve properties of some materials.

**Balamurugan and Perumal (2013)** has suggested that maximum compressive strength, tensile strength and flexural strength can be obtained only at 50% replacement of sand with quarry dust.

**Sumathi A and K. Saravana Raja Mohan (2015)** reported changes in compressive strength of fly ash bricks by addition of fly ash quarry dust and lime.

**Fraay et al. (1990)** reported that the fly ash produced by some of the thermal power plants in India and abroad contains low lime content. Lime is added to stabilize such fly ashes.

**Sivapullaiah and Moghal (2011)** have reported that strength of fly ash, lime mix increases only up to the addition of optimum lime content as higher content beyond the optimum may have deleterious effect.

**Guleria S.P and Dutta R.K (2011)** reported the effect of inclusion of randomly distributed tire chips on the compressive axial load, tensile load, compressive axial strain, diametric strain, post peak behavior in compression, and tension and toughness index of the reference mix containing fly ash+8% lime +0.9% gypsum mix. The results revealed that the compressive axial and diametric strain of reference mix mixed with 5% dry tire chip increased with treatment.

**Kumar Arun U and Biradar Kiran B. (2014)** reported that the addition of the Quarry dust to the soil reduces the clay content and thus with the increase in the percentage of coarser particles, reduces the Liquid limit by 26.86% and plasticity index by 28.48% of unmodified soil.

**Venkateswarlu H et al.,(2015)** reported that when expansive soil is mixed with different percentages (0%, 5%, 10% and 15%) of Quarry dust and the results were found that up to the addition of 10% of stone dust there is an increase in strength parameters beyond it is not effective.

Dutta R.K and Kumar Vaibhav(2015) reported that addition of 1% gypsum along with 10% lime to the fly ash enhanced the unconfined compressive strength by 36.7 times. It was studied that the improvement in unconfined compressive strength is due to fly ash lime reaction as well as the catalyzing effect of gypsum.

### 3. Materials Used

- **Fly ash:** The fly ash used in the study was procured from Ropar Thermal Power Plant, Punjab, India.
- **Lime:** Commercially available lime in the local market was used in the study.
- **Gypsum:** Commercially available gypsum in the local market was used in the study.
- **Quarry Dust:-**Stone dust was obtained from a local stone crushing site and was used in the study.

### 4. Experimental Programme

For carrying out the investigations, fly ash and lime were combined gypsum kept as 0.8% of fly ash and varying the stone dust content in different samples for determining optimum moisture content, maximum dry density and unconfined compressive strength.

In order to determine maximum dry density (MDD) and optimum moisture content (OMC) of Fly ash-stone dust-gypsum mix by varying the lime content as 6%, 8%, 10%, 12%, 14% of fly ash and keeping the gypsum content as 0.8% of fly ash, standard proctor tests were conducted as per IS:2720 (Part VII)-1980.

Unconfined compression strength (UCS) tests were conducted in accordance with IS 4332, Part 5 (BIS 1970). The Unconfined compressive strength was carried out on specimens with varying proportions of stone dust as 0%, 10%, 20%, 30 and 40% for different curing periods and different curing methods.

### 5. Results and Discussion

#### 5.1 Standard proctor test

The optimum dry density obtained from the OMC curve of 8% lime is 1.35g/cm<sup>3</sup> and the optimum moisture content is 29%. The following fig 5.1(a) represents the OMC curves obtained from standard proctor test:-

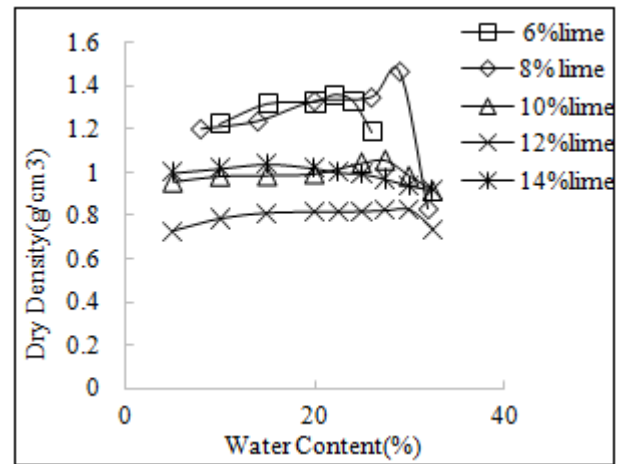


Figure 5.1: (a) Optimum moisture content curves for different % of lime

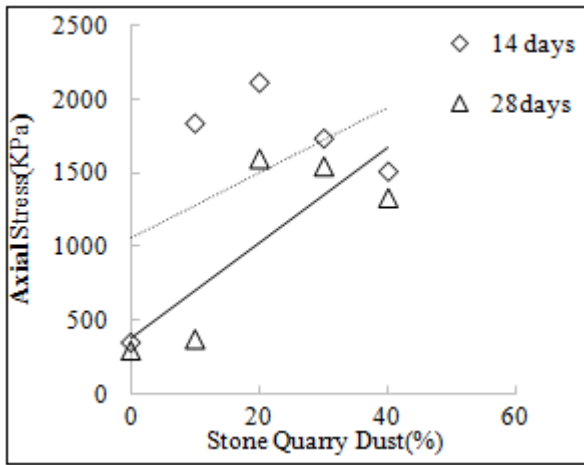
#### 5.2 Unconfined Compressive Strength

Unconfined compressive strength (UCS) tests were conducted in accordance with IS 4332: Part 5: (1970) (Re – affirmed on 03/2001). The strain rate was kept 0.048 mm/min in all the experiments. The proving rings of capacity 2 KN to 5 KN were used for testing specimens cured for 14, 28 with two different methods M1, M2. The UCS increased with curing period and curing method and the increase was significant up to a curing period of 28 days. The maximum increase in UCS of the reference mix with quarry dust was observed when the specimen was cured by method M2. The Unconfined compressive strength of the specimen with 0%, 10%, 20%, 30 and 40% of quarry dust get the different change with different curing periods and different curing methods are explained in Table 5.2(a)

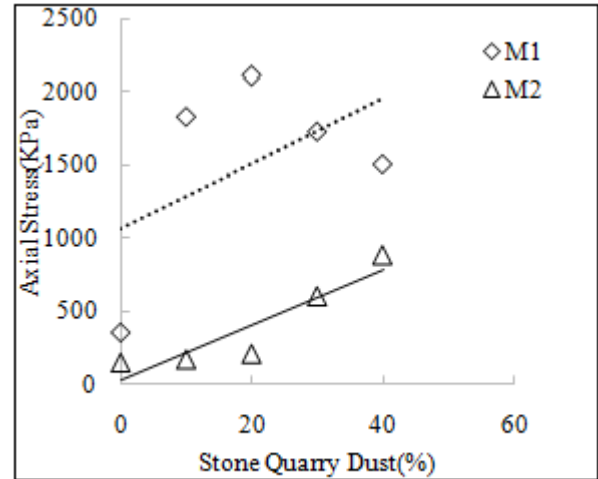
Stone dust proportion	Curing period	M1		M2	
		Axial Strain (%)	Axial stress (KPa)	Axial Strain (%)	Axial stress (KPa)
0	14	21.052	355.018	21.052	150.3608
	28	20.543	298.975	23.234	205.457
10	14	21.052	1837.74	18.421	172.636
	28	21.052	375.901	31.574	350.147
20	14	21.052	2113.40	18.421	210.346
	28	18.421	1596.88	21.053	501.36
30	14	21.052	1735.56	21.052	605.619
	28	21.052	1545.37	23.684	686.780
40	14	21.052	1512.12	23.684	888.242
	28	21.052	1332.14	26.315	1200.839

#### 5.2.1 Variation of axial stress with curing period

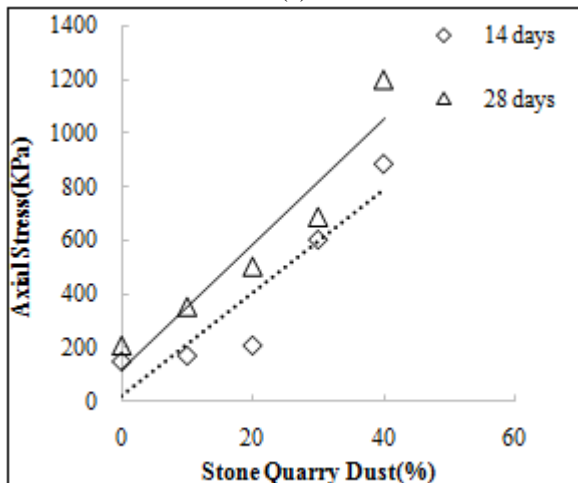
The axial stress of specimen R2014M1 is 2113.404 KPa which decreases to the 1596.887 with the increase in the curing period to the 28 days. In the curing method M2 the axial stress increases with the increase in the curing period. The stress value for the specimen R2014M2 is 210.346 KPa and after 28 days is 501.36 KPa. The figure shows that the axial stress decreases with the increase in the curing period for the method M1.



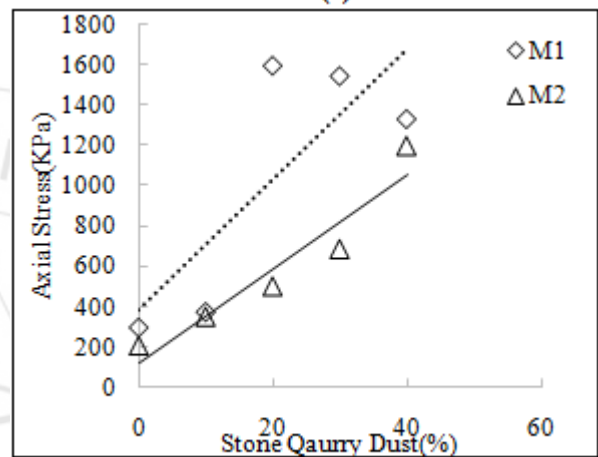
(a)



(a)



(b)



(b)

Figure 5.2 (a) and (b) shows the variation of axial stress with different % of quarry dust by different curing period M1, M2 respectively

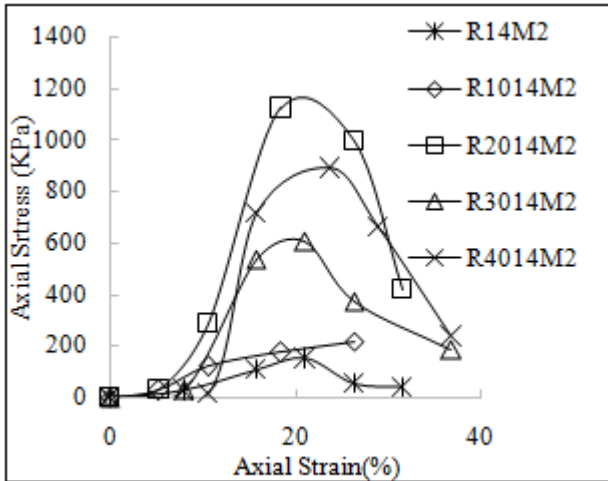
Figure 5.3 (a) and (b) shows variation of UCS of reference mix with quarry dust (%) by M1, M2 methods of curing for curing period of 14 and 28 days respectively.

### 5.2.2 Variation of axial stress with change in curing method

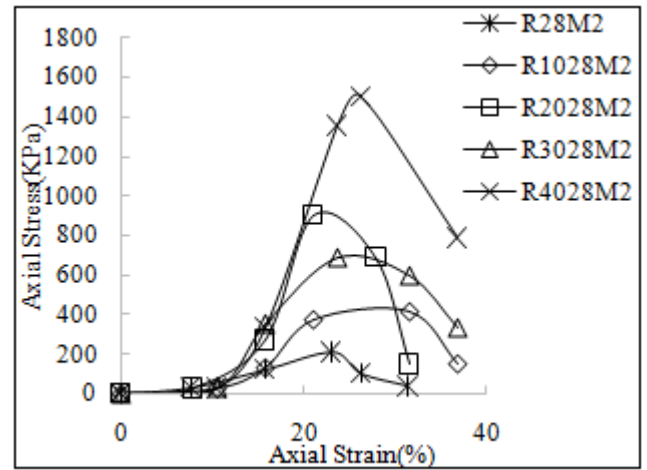
The axial stress of the specimen R14M1 for M1 method of curing was 355.018 KPa, which decreased to 150.360 KPa with the increase in curing method to M2. Similarly for the various proportions of quarry dust the axial stress value decreases with change in curing method. Figure reveals that axial stress of the reference mix and reference mix mixed with quarry dust (0%, 10%, and 20%, 30 and 40%) decreases with the change in the curing methods. The results of the unconfined compressive strength of the reference mix with varying content of quarry dust and cured for different methods are shown in the Fig 5.4

### 5.2.3 Variation of axial stress with increase in the quarry dust

The axial stress of the specimen R14M1 for M1 method of curing is 355.018 KPa, which increases to 2113.404 KPa with the increase in % of quarry dust to R2014M1 after that it decreases to 1512.127 KPa with the increases in % of quarry dust to R4014M1. The axial stress of the reference mix and reference mix mixed with quarry dust (0%, 10%, 20%, 30 and 40%) first increases than decreases with the increase in the % of quarry dust. The results of the unconfined compressive strength of the reference mix with varying content of quarry dust and cured for different methods are shown in the Fig 5.5 (a), (b), (c), (d)

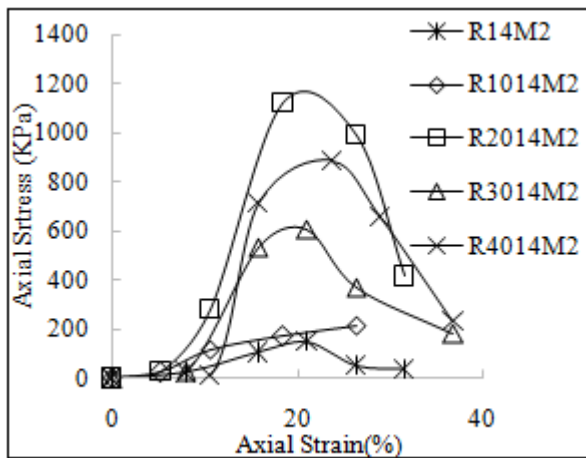


(a)

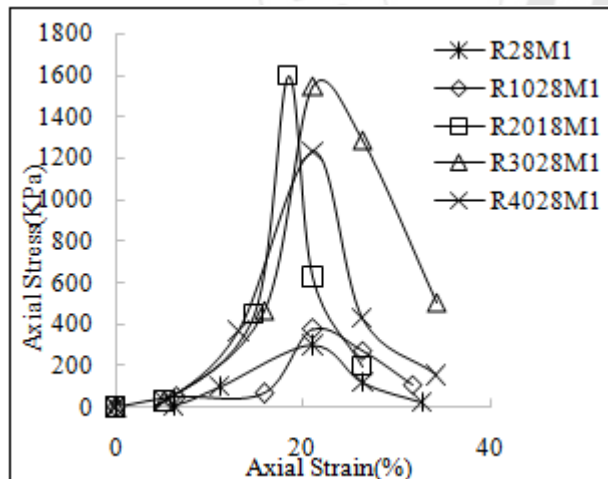


(d)

**Figure 5.4** Variation of axial stress with respect to axial strain with variation of stone quarry dust and (a)M1 method and 14 days curing period;(b)M2 methods and 14 days curing period;(c)M1 method and 28 days curing period;(d)M2 method and 28 days curing period.



(b)



(c)

## 6. Conclusion

- 1) This value of lime along with fly ash and gypsum in proportion of 1%fly ash: 0.8%gypsum gives best results of dry density that can be obtained at a water content of 29%. The maximum dry density obtained is 1.35g/cm<sup>3</sup>.
- 2) The results show that in dry method of curing the compressive strength decreases with the increase in the curing period from 14 to 28 days. While in burlap method of curing the compressive strength increases with the increase in the curing period.
- 3) It was observed that the for the dry method of curing the compressive strength increases upto 20% quarry dust addition and then decreases for 30% and 40% quarry dust addition with fly ash for 14 and 28 days of curing period. In burlap curing method the compressive strength of the specimen increases with the increase in the quarry dust upto 40% for the 14 and 28 days of curing period.
- 4) The results shows that for the dry curing method axial strain remains constant for the 14 days of curing and different proportions of quarry dust while it increases for the 28 days of curing upto 10% and then decreases .For burlap method of curing the axial strain first decreases upto 10% and then starts increasing for 14 days of curing period while it increases upto 10% and then decreases for the 28 days of curing period.

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