

**Mechanical and durability studies on Concrete Containing  
Kota-stone Waste.**

Submitted by

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for the fulfilment of requirements of the degree of Doctor of Philosophy

to the



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MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY  
JAIPUR

### **CERTIFICATE**

This is to certify that the thesis report entitled “**Mechanical and Durability Studies on Concrete Containing Kota-stone Waste**” which is being submitted by **Aditya Rana, ID: 2013RCE9020**, for the partial fulfilment of the degree of **Doctor of Philosophy** in Civil Engineering to the Malaviya National Institute of Technology Jaipur has been carried out by him under my supervision and guidance. I consider it worthy of consideration for the award of the degree of Doctor of Philosophy of the institute.

**(Dr. Pawan Kalla)**  
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The Ph.D. viva voce examination of Mr. Aditya Rana has been conducted by the Oral Defense Committee (ODC) constituted by the Chairman SPGB, as per 9.4.3, vide letter ..... The ODC declares that the student has successfully defended the thesis in the viva-voce examination.

Signature of Supervisor

Signature of External Examiner



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### CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled **“Mechanical and Durability Studies on Concrete Containing Kota-stone Waste”** in partial fulfilment of the requirements for the award of the PhD and submitted to the Department of Civil Engineering, Malaviya National Institute of Technology Jaipur, is an authentic record of my own work carried out at Department of Civil Engineering during the period from July 19, 2013 to January 24, 2017 under the supervision of Dr. Pawan Kalla, Assistant Professor, Department of Civil Engineering, Malaviya National Institute of Technology Jaipur. The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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This is to certify that the above statement made by the candidate is true to the best of my knowledge.

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**Date:** \_\_\_\_\_

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# **Mechanical and Durability Studies on Concrete Containing Kota-stone Waste**

## **Abstract**

Mankind has always exploited the natural resources to satisfy its basic needs. The construction sector is a major consumer of natural resources. Concrete is the second most consumed material after water. All raw materials used for concreting are directly or indirectly obtained by mining the earth's crust. Extensive use of concrete has increased the global consumption of its ingredients. The rising demand for river sand to cater the infrastructural growth has also led to its scarcity in some countries. The enormous and uncontrolled mining of sand from river beds, to fulfil the demand of construction sand has caused a great threat to environment and society. This sort of abusive mining has resulted in loss of water retaining sand strata, deepened river courses, resulted in bank sliding and vegetation loss, exposed intake wells of water supply schemes, disturbed aquatic lives, and lowered water table. Due to the adverse environmental impacts, ban on river sand mining has been reported in various states of the country. The reduced availability and increased cost of river sand has proportionally increased the cost of construction. Moreover, uncontrolled mining of stones to cater the need of coarse aggregates has resulted on mining restrictions. In such a situation, researchers are working to find an affordable alternative to construction aggregates.

Past studies suggest that waste of discarded rubber tyres, silica fume, glass, slag, pond ash, bottom ash, metakaolin, stone etc. can effectively replace a part or the whole of conventional materials used for concreting. Recycling of these wastes as construction material can be a sustainable practice. However, the green concrete so produced needs to satisfy certain parameters for its applicability. In recent years, studies have claimed that waste from dimension stone industry can be effectively recycled into concrete, a practice certainly benefiting the stone as well as construction industries. Kota-stone is a fine grained variety of dimension limestone mined in and around the Kota district, India. After mining, a Kota-stone undergoes finishing operations such as cutting, sawing and polishing. Each operation is

accompanied with the generation of non-biodegradable stone waste. About 58% of the Kota-stone mined ends up as waste. In the mining area of Ramganj Mandi (India), an estimated waste of 100 Mt is dumped on fertile land over a length of 35 km along the highway. The increased cost of waste transportation and management has questioned the economic feasibility of Kota-stone mining in the region.

The economic development of any region depends upon judicious use of its natural resources. The use of Kota-stone waste in concrete may prove advantageous to both the mining and construction sectors. It may provide a sustainable bulk outlet to this waste and will reinstate the economic value of mining and processing waste. Thus, a study with the aim of utilising Kota-stone waste as coarse and fine aggregates in concrete at varying w/c ratio (0.35, 0.45 and 0.55) was undertaken. Along with the strength, durability parameters such as permeability, alkali-silica reaction, carbonation, acid resistance, abrasion, chloride penetration and corrosion of Kota-stone concrete were also studied. The results of strength and durability parameters were validated with the results of microstructural tests such as SEM, TGA, MIP and Ultra sonic pulse velocity. The results suggested that the Kota-stone coarse aggregates can be suitably utilized as a substitute of conventional coarse aggregates in normal and low strength concretes prepared at 0.45 and 0.55 w/c. Also, the manufactured sand prepared from the Kota-stone waste can replace a quarter (25%) of river sand at 0.35 w/c and half (50%) of river sand at 0.45 and 0.55 w/c with an enhancement in strength and durability parameters.

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## **ABBREVIATIONS**

CMA	:	Coarse Marble Aggregate
CS	:	Crushed Sand
DSW	:	Dimensional Stone Waste
EPA	:	Environmental Protection Agency
GCW	:	Granite Cutting Waste
GD	:	Granite Dust
GP	:	Granite Powder
GS	:	Granitic Sludge
HSC	:	High Strength Concrete
KS	:	Kota-stone
LCD	:	Limestone Crusher Dust
LF	:	Limestone Fines
LS	:	Limestone
LSC	:	Low Strength Concrete
MGR	:	Marble Granite Residue
MS	:	Manufactured Sand
PG	:	Powdered Granitic Sludge
PGS	:	Superfine Granitic Sludge
RGD	:	Red Granite Dust
RMA	:	Recycled Marble Coarse Aggregate
RMS	:	Recycled Marble Sand
USGS	:	United States Geological Survey
w/c	:	Water Cement Ratio
WMD	:	Waste Marble Dust