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MANAGING NATURAL SAND DEFICIENCY

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ABSTRACT

Research works are being successively made from the year 2000 onwards to identify a suitable material as alternate to natural sand to be used in construction projects. But at the same time, engineers must focus on various ways in which the use of sand can be avoided or at least minimized wherever possible in the projects. This paper presents various construction techniques which can be adopted for minimizing and or avoiding the use of natural sand. The paper covers some construction practices related to brick masonry, stone masonry and few innovative techniques. Suggestions for future practices along with precautions to use mud and M-sand as building materials are also presented.

1. INTRODUCTION

Civil Engineering is a wide spread spectrum of field, it will long last till the existence of the mother earth and its mountains, forests and rivers. In a construction project, natural sand finds its first place as it readily suits for mortar and concrete owing to its versatile nature of its physical and chemical properties. From 1950s-60s the start of application of RCC flat roof system to late 1990s, natural sand had been used as a most familiar fine aggregate because of its inherent basic qualities and remarkable proximity of sources. May be due to huge number of projects and multistoried constructions; simultaneous failure of rain fall or else the replenishment of sand could have been reasonable, there came an acute deficiency for sand in the recent decades. So, unavoidably civil engineering project personnel sought the solutions to their sand scarcity and started utilizing alternate materials and ways to get over the natural sand deficiency. This paper begins with a short review of selective literature and explains the techniques observed from field in practical application orientation. Later part of the paper is dealt with some of the innovative techniques, few further suggestions for implementation in future in research experiments and real time projects.

2. LITERATURE

Tests made on a set of dry-joint masonry walls showed some opening notes on their mechanical response and the chance to undertake simulation of analytical methods. In axial compression test, dry joint masonry specimens had lesser resistance and more deformations than masonry with mortar joints. For moderate vertical stresses, failure due to combined vertical and horizontal loading was showing nearly a linear failure envelope. Whereas for higher range vertical loads, the capacity of the walls were found severely limited by their out-of-plane buckling.(Peri Roca 2001) DBHS is a dismantle-able building system (structure) that results with a major reduction of C&DW quantity that is 98.34% of bricks used in the construction is found reusable with the balance 1.66% can be recycled. Other parts used in DBHS like steel bolts, nuts and plates can 100% be recycled in post after demolition, because these components can easily be collected recovered and sorted out. (Mohd Faris Khamidi 2006) Natural river sand, by hundred percent Quarry Rock Dust replacement gives either equal or even better performance than that concrete made using Natural Sand. This particularly in view of compressive strength and flexural strength. Tests of many researchers including the present one have shown that the strength of Quarry Rock Dust concrete is 10-12 % more than the reference conventional concrete specimens (R. Ilangovana 2008) A study on comparison of cement and lime stabilized lateritic interlocking blocks prepared using laterite samples from the Olomi area, Nigeria were taken up. The % of stabilizing agents added were 5%, 10% 15%, 20%, and 25% replaced by weight. The testes made with them were compressive strengths, water absorption, and resistance to abrasion. As per the Nigeria Building and Road Research Institute specification 28 days strength must be either equal to or more than 2 MPa. The 10 % cement stabilized blocks only satisfied this. Hence, it was decided that cement stabilized interlocking blocks are better and cheaper than those blocks stabilized with lime in view of quality and economy respectively. (Raheem, 2010).

In UK, application of foundry sand in construction project is familiar. Therefore sand from a UK foundry tested for the properties of compressive strength, ultrasonic pulse velocity (UPV) and absorption. The tests results that the addition of waste foundry sand in concrete causes a regular down fall in, ultrasonic pulse velocity and strength. Addition of such foundry sand increased the water absorption and shrinkage of concrete. However, an acceptable concrete strength can be achieved using foundry sand. (Khatib 2010) Based on the quality tests of fly ash and quarry dust carried out, it is clear that if both of them are together used, the loss in early strength due fly ash may be considered negligible by the gain in strength due quarry dust, and the loss of workability due to later one may be partially negated by the improvement in workability caused by the inclusion of the fly ash. (Rama Raju 2011). The recommendable % of the replacement of sand with the quarry dust, in general is 55% to 75% in view of compressive strength. However by adding the fly ash suitable quantity, replacement of sand with quarry dust 100% can be attained. (Chandana Sukesh 2013).M-Sand can be used up to 50% replacement of fine aggregate gives maximum strength and durability compared to conventional concrete. Based on the experiments it canbe concluded that the replacement of 50% of fine aggregate by M-Sand with 1% steel fibre of aspect ratio 60, produced higher compressive strength, higher split tensile strength, higher flexural strength. This may drastically reduce the consumption of sand and hence protect environment, minimize extraction of sand from sources. (Adams Joe 2013).

Experiment show a result that, 1:6 mix proportion, water/cement ratio of 0.45%, 12 mm size aggregate exhibit more compressive strength rather than other sizes coarse aggregates 6 mm, 20 mm. (K (Satham Ushane 2014) Study made to on the use of local brewery waste and bitter cassava flour as a partial replacement of cement for plastering eco houses in Northern Uganda and found that it has potential for use. The conventional mortar made of cement and sand is not found advisable because they are too strong compared to the strength of eco house walls. Based on the tests, 30-50% replacement with bitter cassava flour is found recommendable for plastering eco house. Local brewery waste and bitter cassava flour mortar is not recommended to be used alone because it's not producing a water resistant finish. But, when mixed with cement, it is recommended as suitable mortar plaster for eco house, particularly, if the mix ratio which satisfies the minimum strength of a stabilized block as specified by the Kenyan standards or any other standard (Okello Thomas 2014). Bricks were prepared were using Sand, Coal ash and bottom ash, and subjected to various tests. Compressive strength and water absorption were found as 7.85 MPa and 13.36%

respectively. Based on the tests made on Brick masonry piers concluded that in piers where rich cement mortar was used, the bricks failed and in the piers where leaner mortar was used the masonry joint failure occurred. In general, for the increase in lime and coal bottom ash quantity, strength increased but the water absorption decreased. In all, these bricks made of coal ash and bottom ash were as compact, homogeneous in structure and free from defects such as holes, lumps etc. Hence, theses bricks can be commercially used advantageously in view of its compressive and simultaneously will solve disposal problem of ash, which or else it causes a serious hazard. (Surender K 2016) The aggregate size of 10mm was taken as the optimum result because the highest figures were recorded for the split tensile test and the compressive strength test after a curing period of 28 days (Shahiron Shahidana 2017). Copper Slag may be replaced for sand from 40 % to 60% without altering cohesive property and flexural strength. Granulated Blast furnace slag may be used to replace sand up to 75%, more over it is reported that the higher replacement levels give higher compressive strength. Out of the disposal of thermal power plants, 15 to 20 % is considered as bottom ash, which is the residue after the fly ash. Almost 30% of replacement of natural sand by this Bottom ash is said to be optimum in view of strength especially after reasonable age allowance. Quarry dust can be used to replace natural sand up to 50 to 70 %. However, in certain cases 100 % replacement also being made with the addition of other materials like fly ash. Foundry sand having got notable portion of silica, it can also be used for the replacement of natural sand up to 30% advantageously in places where it is available like industrial belts. Construction and demolition waste denoted shortly as C&D waste consisting fine and coarse aggregate can be used for total replacement of fresh sand and coarse aggregate. But as per reports these C&D wastes predict 10 to 15 % lesser strengths compared to the use of fresh sand and coarse aggregate. So, the use of C&D wastes may be safely restricted structures of minor importance such as floors, pavements, drains, revetments, canal linings, diver walls, compounds and dwarf walls etc., Govt. must take initiatives to motivate all relevant stakeholders in using this C&D wastes, by first installing the recycling plants at appropriate places which is accessible with simplified or minimum formalities (Kapil Menghrani 2018).

1. Scope

The literature noted above, showed only the attempts which have been taking place in research field in the recent two decades mainly focusing various alternates for natural sand that too majority of them focus mainly in preparing concrete. Papers mentioning alternates for mortar is scanty. At the users end, in rural and urban areas people have been adopting many techniques in avoiding the use of sand or minimizing the quantity of sand. Therefore the paper bring forth the outdated valuable practices of using mud as alternates to sand along with some limitations to be borne in mind when mud is used. Also various possible techniques, points to be observed in planning, designing and execution of projects in addition to citing the innovative practices for minimum use of sand or any material in place of sand.

3. Past and Present Practices

In construction field, general practices are continuously adopted. An exact demarcation is so difficult to do between past and present. The traces of history reveal that the first cement production in India was started in 1914 at Porbandar, Gujarat around 106 years before. Its wider applications must have come somewhere around 1950s. Within the scope of this paper, however, the period before 1950, may be regarded as past. After that the recent years till date may be considered as present.

3.1 Brick Masonry Practices

3.11 Past years: The art of combining individual blocks of masonry construction itself was too early to get developed. Walls were made of lumps of earth thoroughly mixed with gravel and made only to shorter height but with larger width. The roofs were made as slanting one which normally consists of closely arranged dry small branches of trees, dry poles or sticks covered by grass or thatches of palm trees. Thus, they were projected outside the wall for draining the rainwater. As far walls are concerned, main material used was earth, mud, mud stabilized with various fibrous materials like pieces of dry weeds, straw etc.,

3.12 Use of Mud mortar

The mud mortar can be prepared using excavated earth or red earth. It is added with sand for 1:1 ratio for imparting strength to mortar. Otherwise, mere earth or red soil is sticky in nature; hence it cannot be in workable state. Mud mortar is suitable for both wall construction, and plastering. Place at where rice husk or cow dung is available, Dry powder of it, from 5 to 10 % is added to mud mortar to increase further strength and workability.

3.13 Mud Plastering

Mud plastering is usually done both for inner and outer plastering of walls. It eliminates the use of sand. It is mixed with gravel or local excavated earth. It has good thermal resistance. It can be white washed for good aesthetic look. The mud plastered wall need to be maintained after every rainy season, as it is prone to get damaged by the rain splash.

3.14 Mud for wall and concrete

Mud concrete is mainly adopted for providing foundation leveling course, in shallow foundation of residential buildings up to two storeys with RCC roofing. To adopt this care is necessary to maintain proper drainage system in foundation.

a b c d e f

Fig. 1: Walls without Mortar and Minimum Mortar.

Figure 1 Shows Walls without mortar and minimum mortar. The figure 1a,b,and c are regarded as past category. Whereas figure 1 d, e and f are regarded as present category. As in figure 1, a) and b) Natural excavated earth lumps directly used in wall, c) shows a wall in which lower part is made of earth / mud, the upper part was made of brick work, d) huge walls and buttresses left without plastering, e) a residential building constructed in ground floor with framed structure. The columns and beams are stopped at ground floor roof level, in first floor is raised similar to a normal load bearing structure and its wall not plastered and e) wall made of brick but minimization is adopted in by not adopting uniform thickness of wall for 230 mm, it consists of piers at suitable interval. The table.1, presents type of mortar & type of roofing for adopting c/c distance of brick masonry piers. All these are presented for having used locally available material, and depends on importance of the structure, loading conditions, very carefully minimization of mortar and hence the minimum use of sand is resorted to.

Table 1: Type of Mortar & Type of Roofing for C/C distance of Brick Masonry Piers.

Sl. no.	Piers size (mm)	Binding material for Mortar	Type of roofing	c/c Spacing piers (mm)
1	230 x 230	Mud or Lime	AC Sheet / Other light roof	2400
2	230 x 230	Cement	Single storey RCC	3000

3.2 Stone Masonry Practices

3.21 Dry stone masonry

Dry stone masonry in which only rough stone blocks are manually arranged in such a fashion so that proper bonding or interlocking is achieved by suitably placing small wedge shaped pieces of stones wherever needed. So, no mortar packing is done. This kind of masonry is generally adopted for agricultural fields, retaining walls, compound walls, garden walls, dwarf walls etc., This dry stone masonry can also be used in open foundation of residential buildings up to two stories. It is to be noted that this type of masonry if adopted in shallow foundation, it can safely transmit vertical loads, at the same time will act as a perfect drainage system. It would allow only water to pass through the boulder stone media; not causing any dislocation of stones. As a general precaution, from foundation, a suitable drainage system must be provided, so that in heavy rainy period; neither water logging occurs nor surrounding soil erosion begins.

a b c d e f

Fig. 2: Stone Masonry without Mortar and Minimum Mortar.

Figure 2 shows stone masonry without mortar and minimum mortar. In it, a) and b) are dry stone masonry without mortar, c) compound wall with packing mortar only face and back left unfinished, d) random rubble masonry in a basement wall finished with pointing and e) & f) coursed rubble masonry wall finished with pointing.

4. Precautions

4.1 Precaution for using Mud in Construction

Mud is a basic construction material readily available in local / nearby places. Mud when prepared with proper ratio of gravel, pallam sand and water it will give sufficiently good strength for mortar, which is useful for both masonry construction and plastering. So long as the mud mortar is protected against ingress of moisture. It will withstand in its state of dry and stiffened nature. And therefore it will have its full strength. Hence, in dried mud mortar in structures is always reliable, and serves its purpose. So, rather than the use of mud mortar in finishes of outer walls which are susceptible for ingress of moisture, the rendering of inner walls can be very well done with mud mortar. Unavoidable if mud mortar is used in outside, where protection against rain by roof projection is difficult or found not affordable, bitumen or coal tar coating can be made for increasing its durability(CBRI, Roorkee).[14]

4.2 Precautions to use M-Sand

M-sand is obtained from stone quarry, in which, to add to the volume, people add stone powder also. The stone powder thus mixed with the M-sand calls for more water content, while making mortar. Because, while mixing water to make mortar; the larger powder content will increase the surface area to be wetted. Also, each and every stone dust particle need to be coated by the cement slurry, thus the increased amount of cement is required to make a workable mortar. In turn, the increased cement content will also call for increased water content to wet the cement particles. Hence, enough care should be taken on water cement ratio for preparing and achieving better performances of mortar using the M-sand.

5. Future applications

5.1 Avoiding / minimizing inner masonry partitions

As far as possible load bearing masonry partition walls can be avoided or minimized. Partition may conveniently be arranged with the use of existing furniture viz. steel Almera or wooden wardrobes or any movable furniture items, depending upon the privacy need.

5.2 Using larger sizes of masonry blocks

In place of normal standard brick of size 230mm x114mm x 75mm, if solid or hollow cement concrete blocks or similar larger masonry blocks of size 375mm x 200mm x 200mm is used, it replaces 7 normal size bricks. Hence, it reduces as much as 60 % of number of bed joints in the masonry. However, limiting weight of such blocks within the range of 12 to 20 kg will avoid difficulties in handling on project site. The total number of joints is reduced, volume of mortar is reduced and hence the sand usage is minimized.

5.3 Adopting Innovative Techniques

Rat-Trap Bonding for 230mm thick brick walls if adopted a direct savings of 25% of bricks and 30 % of mortar can be saved, apart from achieving good interior thermal effect. Similarly, by using the filler slab designs 20 to 25 % of materials used for floor and roof concrete can be minimized and hence, sand consumption can be minimized (Balasubramani 1995). Figure 3 shows Innovative floor systems which are one way ribbed slab by partially precast type during construction and ceiling view of RCC filler slab. The partially precast slab needs only around 35 mm of screed concrete. Hence, apart from the topping concrete, the use of hollow blocks minimizes the volume of concrete consumption and therefore uses minimum sand. The RCC filler slab saves around 20 % quantity of concrete and 25 % of plastering, hence reduces the quantity of sand required Balasubramani N. (2016).

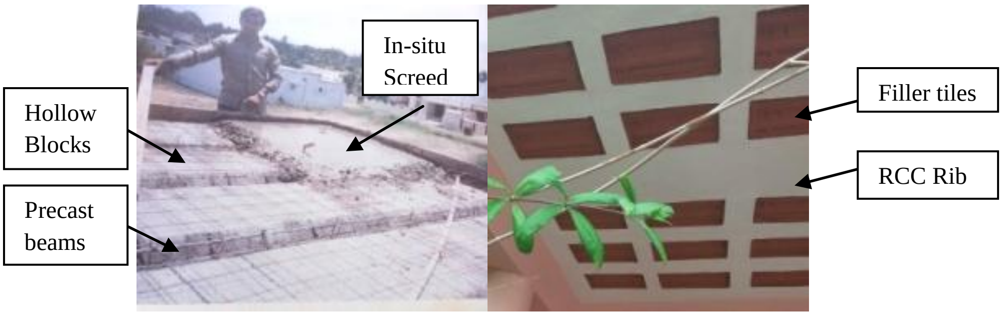

Fig. 3: Innovative Floor Systems.

5.4 Avoiding over designs

In lot many places the rational design are not adopted in field. Even though, a technically qualified engineer provides the design, for psychological reasons or for any other reason end user changes the design result. It leads to the use of oversize members and finally cause resource shortage. For example, instead of using half brick wall, using 230 mm wall, the entire masonry volume gets doubled. It is unavoidably increases the size of lintel too. So, every attention must be paid to adopt rational design elements with utmost care by striking a balance of safety and economy.

5.5 Optimizing building measurements

Not only the component design can serve the purpose of reduced consumption of materials, but also each and every building must be planned and designed according to the purpose of building, based on standard guidelines like Architectural standards or Building standards, like National Building Code of India (NBC -2016).

5.6 Channelization for recycling material

Remodeling of buildings, destroying existing structures and constructing new ones in the same place is quite often takes place in many places, in especially urban area and developing towns. There debris of the construction items are thrown on soil or it is used hardly for reclamation of low lying areas. By suitably modifying and improving such disposal methods, and by formulating a channelized procedure, a reasonably good percentage of the old building materials can be reused again advantageously, to minimize the consumption of natural resources such as sand, coarse aggregate and other materials. For which an interlinking forum between practicing engineers and government department will be very much useful.

5.7 Recent Techniques

There are many newer techniques, which have come in the practice of masonry construction in the recent decades. Use of stabilized mud block, concrete filled stone blocks, interlocking of blocks with special dry joints without mortar, use of clay blocks etc., can also be resorted to, in reducing the use of sand.

CONCLUSION

1. Various past and present construction techniques adopted in field avoiding and minimization of consumption of natural sand is presented.
2. Precautions to use mud mortar and M-sand are presented.
3. Points for future applications are techniques are presented.
4. The techniques illustrated will be more useful for budding engineers to study, compare, co-relate many points for further research out comes to identify an indigenous method.

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REFERENCES

1. Peri Roca et al., Mechanical Response of Dry Joint Masonry, Jan, Universitat Politècnica, https://www.researchgate.net/publication/237209817, 2001.
2. Mohd Faris Khamidi, Dry-Masonry Brick House System As An "Adaptable Building" Model For Sustainable Housing, 18-19 Sep, Universiti Sains Malaysia, Penang, Malaysia, 2006.
3. R. Ilangovana et al., Strength and Durability Properties of Concrete Containing Quarry Rock Dust as Fine Aggregate, ARPN Journal of Engineering and Applied Sciences, 2008; 3(5): 20-26. ISSN 1819-6608.
4. A.A. Raheem, A Comparative Study of Cement and Lime Stabilized Lateritic Interlocking Blocks. The Pacific Journal of Science and Technology, 2010; 11(2): 27-34
5. Jamal M Khatib et al., Foundry Sand Utilisation in Concrete Production, 2nd Int. Conference on Sustainable Construction Materials and Technologies, June 28-30, University of Politecnica Delli Marche, Ancona, Italy, 2010.
6. M.V. Rama Raju, et al., Study of Properties of SCC using 'Quarry Dust' and 'Fly Ash' K.V. Vivek, Dr.T. Siva Shankar Reddy and P. Srinivas Reddy, Pg.No. 323 to 332, International Journal if Engineering Science Research, Aug-Sep 2011; 02(04).

7. Quarry dust- Chandana Sukesh, Partial Replacement of Sand with Quarry Dust in Concrete, International Journal of Innovative Technology and Exploring Engineering, ISSN: 2278-3075, May 2013; 2(6): 254-258.
8. K Satham Ushane et al., Investigation of No-Fines Concrete in Building Blocks, International Journal of Structural and Civil Engineering Research, ISSN 2319 – 6009, Nov 2014; 3(4): 170-177.
9. M.Adams Joe, Experimental Investigation on The Effect Of M-Sand In High Performance Concrete, American Journal of Engineering Research (AJER) e-ISSN:2320-0847p-ISSN: 2320-0936, 2013; 02(12): 46-51.
10. Okello Thomas, Use of Local Brewery Waste and Bitter Cassava Flour as A Partial Replacement of Cement for Plastering Eco Houses, MSc., Civil Engg. Thesis, Pan African University Institute for Basic Sciences, Technology and Innovation, 2014.
11. C&D waste- Shahiron Shahidana, et al., Utilizing Construction and Demolition (C&D) Waste as Recycled Aggregates (RA) in Concrete, 2016 Global Congress on Manufacturing and Management, Science Direct, Procedia Engineering , 2017; 174: 1028 – 1035.
12. Surender K et al., Performance of bricks and brick masonry prism made using coal fly ash and coal bottom ash, Advances in Concrete Construction, *2016; 4(4):* 231 -242.
13. Kapil Menghrani, The Master Builder, July 2018; 20(7): 68-72.
14. Advances in Building Materials and Construction, CBRI, Roorkee.
15. N. Balasubramani, "A Study of Physical and Structural Behaviour of wall and Roof Elements" – A thesis of Master of Engineering, PSG College of Technology, Bharathiar University, Feb 1995.
16. N. Balasubramani, et.al., "Eco-Friendly Building Techniques And Their Viability" Books of Abstracts ICEE-2016: The 2nd International Conference on Environment & Ecology, 2016; 7-9: 276.
17. SP7:2016, National Building Code of India, 2016; (NBC 2016).