Utilization of Used Foundry sand and Hypo sludge in Sustainable Mortar: A Review

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Abstract: Nowadays the concrete materials are reduced in earth surface so we are in need to find out the alternative materials to concrete. Mortar is one of the most used construction material in construction industry. Using Foundry sand as an alternative of river sand is the best way to save natural resources. Hypo Sludge which is generated from paper industries contributes to a larger extent to solid waste.The paper here presents a detailed literature review on making Sustainable Mortar from waste materials which saves energy and conserves natural resources which can lead to a safe sustainable environment and also help to maintain economical environment.

Keywords: Foundry sand, Hypo sludge, Sustainable mortar

I. INTRODUCTION

Millions of tonnes of solid industrial wastes are produced in India every year.Nowadays the concrete materials are reduced in earth surface so we are in need to find out the alternative materials to concrete. Mortar is one of the most used construction material in construction industry and it has become an excellent and important construction material in the infrastructure and industrial development due to its various advantages. River sand has been the most widely fine aggregate in Mortar and overuse of river sand has led to various harmful results.Utilization of industrial wastes like Hypo Sludge and Foundry Sand in Sustainable Mortar and problem of disposal can be solved. It also economizes the Mortar by partially replacement of cement and Natural sand by using such industrial wastes.

Foundry Sand

Foundry sand is high quality silica sand with uniform physical characteristics. Foundry sand is a by-product of both ferrous and non-ferrous metal casting industry. Because of its high thermal conductivity, it is used for moulding process in foundry. This sand is utilized in different processes for number of times before it becomes a by-product. The Indian Foundry Industry is well established. According to the recent World Census of Castings, USA, India Ranks as 2nd largest casting producer in the world**.[7]** There are about 50,909 foundries in the world from which 6 – 10 million tons of foundry sand is totally discarded on to the ground. The Metal Casting Industry in India are well established in India. It is estimated that they produce around 9.344 Million Tons of various grades of Casting product as per standards. In India there are 4500 foundry units approximately. So, the waste produced generated from this sector equally contributes to environmental degradation. **[13]**

Hypo sludge

From paper manufacturing industry, Hypo sludge is generated as waste. During de-inking and re-pulping of paper it is generated as by-product. The paper making industries generates a large amount of solid waste. The industries recycle the paper fibres and try to use it at maximum. As they become too short or weak to make high quality paper these paper fibres can be recycled only a limited number of times. Since many years India's share to the world's total production of paper and paper products have been rising. It has been found that the values have risen from 0.68 % in 1981 to 0.84 % in 1990. The government has taken multiple policy initiatives which have lead to impressive growth of various types of paper and paperboard. The data shows that India has contributed for about 2.25 % of world's production in 2010. Low calcium, maximum calcium chloride and minimum amount of silica contains in hypo sludge. Due to this property it behaves like cement. [**31]**

II CRITICAL LITERATURE REVIEW

Following are the critical literature reviews on papers of Sustainable Mortar production using different type of industrial solid waste:

Siddique et al. (2009) investigated the mechanical properties of concrete mixtures in which regular sand was partially replaced at 10%, 20%, and 30% with used-foundry sand (UFS). Compressive strength, splitting-tensile strength, flexural strength, and modulus of elasticity of concrete mixtures increased with the increase in foundry sand contents and that can be effectively used in making good quality concrete and construction materials.**[26]**

Singh et al. (2012) investigated the possible large scale utilization of Waste Foundry Sand in making concrete as partial replacement of fine aggregate. Partial replacement of sand with WFS (up to 15%) increases compressive strength, splitting tensile strength and modulus of elasticity of concrete. It was concluded that Waste Foundry sand can be used in making structural grade concrete.**[27]**

Ahmad et al. (2013) studied the possibility of using paper sludge ash as partial replacement of cement for concrete. It was found that the compressive strength can increase by 15% when Waste paper sludge is used in place of cement in the concrete mixture up to 5% by wt. The experimental study shows that if paper sludge ash content is increased, the water absorption percentage also increases thereby decreasing the workability of concrete mix. The waste paper sludge ash in concrete can prove to be economical if it is used in right proportion.**[2]**

Solanki et al. (2013) carried out research on the strength of concrete by partial replacement of cement using paper sludge to prepare a mix M20 grade. The optimum replacement was found at 30% at which maximum compressive strength was obtained. For temporary structure design mix up to 40% replacement can be used. According to the nature of concrete formed, it can be used for temporary shelters for those affected by natural disaster. Also this material is economically feasible.**[29]**

Pitroda et al. (2013) studied the effect waste paper sludge on cement. Concrete mixtures were produced and tested. The results were then compared in terms of strength with the conventional concrete. 10% increase in the proportion of hypo sludge result in increase of compressive strength. Further increase in the quantity of hypo sludge results with the reduction in the compressive strength of the specimen.**[20]**

Pitroda et al. (2013) studied the properties of Hypo Sludge in concrete to check its durability. The water absorption of Hypo Sludge in concrete shows lower water absorption at 10% replacement for M25 and M40 grade concrete. The water absorption of Paper Industry Waste concrete shows lower water absorption at a replacement level of 10%. For an innovation supplementary cementitious construction material, Hypo Sludge can be used.**[19]**

Pathariya et al. (2013) carried out a research to produce a low-cost concrete which can be eco-friendly in nature. The compressive strength increases with increase in partial replacement of waste foundry sand which was concluded and maximum compressive strength is obtained at 60% replacement. It was found that split tensile strength decreases with increase in percentage of waste foundry sand. Utilization of WFS can solve the problems of disposal. If such materials are reused maintenance cost of land filling can also be reduced. This study shows a path towards areas of innovative building material and development in construction sector.**[17]**

Sohail et al. (2013) studied that foundry sand has effectively use to other industries. From the experimental study, result shows that Waste Foundry Sand can be effectively used as a replacement of natural sand in concrete. The maximum compressive strength was achieved at 50% replacement of fine aggregate with waste foundry sand. Increase in flexural strength of concrete was observed at 50% replacement. They also concluded that Flexural strength of concrete decreases if the replacement is increased after 50%.**[15]**

Bhimani et al. (2013) carried out a research on use of foundry sand in concrete. As an alternative to traditional concrete the foundry sand was used as a fine aggregate replacement and material was tested. It was observed that the water absorption was decreased up to 50% replacement of fine aggregate by used foundry sand. Maximum compressive strength was achieved at 50% replacement. The study proposes to reduce Environmental effects from wastes and disposal problems. Like foundry sand a better measure is approached by an innovative Construction Material.**[3]**

Kacha et al. (2014) studied the utilization of waste foundry sand in the concrete. Due to the addition or replacement of fine sand with used foundry sand the result shows positive changes and improvement in strength and durability properties of the conventional cementitious concrete. It was found that workability decreases with the increase of foundry sand content because of very fine particles. They concluded that towards the development of environment friendly and sustainable cementitious concretes utilization of used foundry sand holds a great potential.**[28]**

Kumar et al. (2014) investigated the used foundry sand as natural sand replacement in concrete. Compressive strength, split tensile strength and flexural strength of concrete specimens increased, with increase in fine aggregate replacement by foundry sand. It provided maximum strength at 50 % replacement. Decrease in strength properties was observed. Making concrete from recycled materials saves energy and conserves natural resources.**[11]**

Khuram et al. (2014) carried out a research on utilization of three types of used foundry sand with bentonite clay, with sodium

silicate & with phenolic resin as partial replacement of fine aggregates in concrete. The compressive strength of concrete was considered as the testing parameter. River sand replaced by used foundry sand at 10%, 20% and 30% in this study. The workability increased with increase in replacement levels. Compressive strength increases with increase in curing age in all cases and at 28 days of curing. It was observed that strength decreases with increase in percentage replacement.**[8]**

Siddique (2014) presented an overview of physical, chemical, and mineralogical composition of the concrete. He found that waste foundry sand adversely affects the concrete when it is used as partial replacement of fine aggregates. The slump and water absorption of the concrete were adversely affected. It was found from the research that Foundry sand can be utilized as a replacement for regular sand and fly ash in making controlled low-strength materials.**[25]**

Chakraborty et al. (2014) carried out the research work to evaluate the optimum percentage of hypo sludge to be used for making concrete. Both compressive and tensile strength of concrete is found to be increased upto 20% cement replacement level as compared to the OPC concrete. , the maximum strength gain is observed at 10% replacement level and hence can be considered as optimum level. Replacement of hypo sludge with cement also has markedly reduced the cost of construction which was been dumped making environmental hazard.**[4]**

Khan et al. (2014) carried out the research work to develop low cost concrete from paper industry waste. He focused on use of cheaper materials as substitute for concrete materials.With the 10% replacement of hypo sludge the results were compared to traditional concrete and it was observed that the strength has increased. At a 20% replacement of Hypo sludge compressive strength and flexural strength remain same and after strength is decrease with 30% replacement. Utilization of Hypo Sludge can lead to increase in strength and also cost reduction in the concrete can be determined.**[7]**

Balamurugan et al. (2014) examined the behaviour of concrete on addition of Hypo Sludge in different proportions. The study was concluded on the basis was tests like compression strength and split strength. Compression strength has been increased with the 10% of replacement of hypo sludge in concrete. Use of hypo sludge in concrete can minimize the cost of construction. The gainful utilization of waste product into concrete can reduce the environmental problems.**[22]**

Seyyedeh et al. (2014) studied the use of pulp and paper industry wastes in various concrete mixes. The use of pulp and paper industry wastes can be used as recycled material in concrete manufacturing. The disposal cost can be reduced if this waste is used in construction industry. It can also help in making a greener concrete material for construction.**[23]**

Lodhi et al. (2015) investigated the utilization of paper waste as additional material in concrete mixes to be used for housing projects. Slump value of concrete mix remained same compare to control mix at addition of 10% paper waste. On addition of 15% of paper waste, the decrease in slump value was observed. Water absorption of concrete was decreased with 10%, 15% and 20% of paper waste addition. The cost of production of concrete, when compared with control mix gets reduced with addition of 10%, 15% and 20% paper waste respectively.**[12]**

Shermale et al. (2015) carried out the research work on the production of low cost concrete by replacement of cement with hypo sludge. The strength of concrete has increased compare to conventional concrete at 10% replacement of Hypo sludge with the cement. At a 20% replacement of Hypo sludge compressive strength, Flexural strength and Split Tensile Strength remain same. It was found that further replacements lead to decrease in strength.**[24]**

Amritkar et al. (2015) carried out an experimental work to study the mechanical properties like compressive strength, split tensile strength and flexural strength of concrete. Artificial sand was replaced by foundry sand as fine aggregate. Test result showed a negligibly increase in strength and durability properties of concrete by addition of WFS as a partial replacement of fine aggregate.**[1]**

Swapna et al. (2015) investigated the properties of mortar using waste foundry sand obtained from ALSTOM industry Shahabad. And Tested for physical properties of various material used in mortar such as cement, local sand and foundry waste sand were conducted. The compressive strength values for masonry mortar were 5.10, 3.70,3.80 N/mm^2 and plastering mortar were 4.60, 2.95, 3.23 N/mm^2 for local sand, weathered sand and burnt black sand respectively. Chloride content of local sand and FWS is nearly same. Chloride content of all the sands are within the limits. However, results obtained by FWS are satisfactory as per the Indian Standard**.[30]**

Jagtap et al. (2015) examined utilization of waste foundry sand in civil engineering practice.Compressive strength and split tensile strength increases on increase in percentage of waste foundry sand as compare to traditional concrete. Maximum Compressive strength is obtained at 40% replacement of fine aggregate by waste foundry sand. The problems of discarding and maintenance cost of land filling is minimized by the effective utilization of WFS. The result shows that the economical, sustainable and high strength of concrete is produced.**[5]**

Raval et al. (2015) studied the usage of this waste material(Foundry sand) in concrete. Based on experimental investigation Compressive strength, and flexural strength of concrete is increased with the replacement of natural sand by foundry sand, providing maximum strength at 30 % replacement, and beyond that the strength parameters are decreased. Making concrete by using recycled materials(foundry sand) saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainable environment.**[21]**

Pitroda (2015) examined the gainful utilization of fly ash and hypo sludge in concrete mixture. The results show that for M40 grade of concrete, 10% hybrid mix of fly ash and hypo sludge replacement with cement gives the design strength at 28 days. The cost analysis shows that percentage cement reduction decreases cost of concrete. It was observed that strength also decreased. The hybrid mix at 10% can give us an innovative supplementary of cementitious Construction Material.**[18]**

Makwana et al. (2015) studied the physical and chemical properties of foundry sand and ceramic waste. Reusing these foundry sand and ceramic wastes in concrete can be very beneficial situation for society. And conclude that making more sustainable concrete by reducing non-renewable resources like cement, aggregates and also lead to solve the environmental problems related to land fill wastes. They determined that up to 20 to 30% replacement of ceramic waste and foundry sand in concrete improved the physical and mechanical properties of concrete with compare to conventional concrete. So, that waste can be used in concrete to reduce disposal problems on land and environmental problem.**[13]**

Alam et al. (2015) presented an experimental study on use of hypo sludge in cement concrete. The experimental results conclude that hypo sludge replacement with the cement at 20% gives as much strength as conventional cement concrete. It was found that as the percentage of hypo-sludge in the mix increases, the slump decreases. Also, 10% replacement of cement by hypo sludge gives about 11% higher strength than pure concrete. This research help to preserve the environment as its application reduced the requirement of cement's raw material.**[14]**

Kumar et al. (2016) described the use of Paper Sludge Ash and Foundry Sand in concrete. M25 grade of concrete was considered for the study. The maximum split tensile strength was achieved at mix with 40% replacement of foundry sand and 5% replacement of Paper Sludge Ash.**[9]**

Kaur et al. (2016) carried out a research on experimental investigation of the strength of concrete blended with hypo sludge. At 10% replacement the maximum compressive strength and splitting tensile strength was achieved. The cost analysis indicates that decreases the cost of concrete, but at the another end strength decreases. This material can be used in the manufacturing of temporary shelters at the time of natural disasters where strength is not considerable factor.**[6]**

Talsania et al. (2016) carried out research by replacement of the (OPC) cement with the hypo sludge. At the 20% replacement Compressive strength and flexural strength is increased. W/C ratio also increased respectively. As a result utilization of Hypo Sludge in concrete Compressive Strength and Flexural Strength was increased.**[31]**

Naik et al. (2017) has carried an experimental investigation on Used Foundry Sand waste to be utilized for the preparation of concrete as partial replacement of sand. At 40% replacement of Used Foundry sand with sand maximum increase in strength properties was achieved. It was then compared to conventional concrete. The results show at 40% replacement of used foundry sand with silica fume showed better performance than with Fly ash. At 40% replacement the maximum compressive strength and flexural strength was achieved.**[16]**

Kumar et al. (2017) investigated the replacement of fine aggregates and cement with used foundry sand and hypo sludge in various percentages in concrete. The experiments were carried out at various replacement levels of 10%, 20%, 30%, 40% by foundry sand with sand and 10%, 20%, 30% by Hypo Sludge with cement in M_{20} grade of concrete. Compressive strength, split tensile strength, flexural strength of the concrete is increased at the replacement of 20% of hypo sludge and 30% of foundry sand. The maximum compressive strength and split tensile strength was obtained at this replacement.**[10]**

The following table 1 shows the literature review papers and its comparison.

Table 1 Literature review papers and its comparison

Author	Year	Utilization Area	Material Used	Addition/ Replacement	Tests	Increase/ Desirable
Kumar M.Sathees	2017	Concrete	Foundry sand Hypo Sludge	Replacement	Compressive strength	Increase
NaikSugali Venkatesh	2017	Concrete	Foundry sand	Replacement	Compressive strength	Increase

Author	Year	Utilization Area	Material Used	Addition/ Replacement	Tests	Increase/ Desirable
Talsania Siddharth	2016	Concrete	Hypo Sludge	Replacement	Compressive strength	Increase
KaurManmeet	2016	Concrete	Hypo Sludge	Replacement	Compressive strength	Increase
Kumar Anil	2016	Concrete	Foundry sand Hypo Sludge	Replacement	Compressive strength Flexural Strength	Increase Increase
MehtabAlam	2015	Concrete	Hypo Sludge	Replacement	Compressive Strength	Increase
MakwanaShyam	2015	Concrete	Foundry sand Ceramic waste	Replacement	Compressive Strength	Desirable
Pitroda Jayeshkumar	2015	Concrete	Hypo sludge	Replacement	Compressive Strength	Desirable
Raval Amitkumar D.	2015	Concrete	Foundry Sand	Replacement	Compressive Strength	Increase
JagtapMinakshi B	2015	Concrete	Foundry sand	Replacement	Compressive Strength	Increase
Swapna	2015	Mortar	Foundry sand	Replacement	Compressive strength	Desirable
AmritkarShubham S	2015	Concrete	Foundry sand	Replacement	Compressive Strength Flexural Strength	Desirable Desirable
Shermale Y.D	2015	Concrete	Hypo sludge	Replacement	Compressive Strength	Increase
LodhiRavindra Singh	2015	Concrete	Paper waste	Addition	Compressive Strength	Increase
S Chakraborty	2014	Concrete	Paper waste	Replacement	Compressive Strength	Increase

III CONCLUSION

Based on literature review the following conclusions are drawn:

[1] Using of Industrial waste like Foundry sand and Hypo sludge in Concrete shows favourable compressive strength.

[2] A better measure towards the sustainable environment can be undertaken by gainful utilization of hypo sludge in mortar.

[3] The material is economically feasible for the temporary shelters during natural disasters where strength is not considerable factor.

[4] The production of waste in Metal industries can be reduced by the use of waste foundry sand in concrete.

[5] The effective use of Waste foundry sand as fine aggregate can be done in place of conventional river sand.

[6] Beneficial use of waste foundry sand and hypo sludge in mortar can prove as an eco-friendly construction material.

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