To evaluate the effect of Synthetic polymers to control Dampness in Structural Members

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Abstract

The quality of construction projects can be enhanced by reducing the defects in the projects during and after construction. Some defects in the construction projects are harmful for the durability and structural stability and some of them are harmful for the indoor air quality and building aesthetic. Dampness is main defect that reduces the life of building as well as the comfort level for the resident of the building. Bitumen coating has been used for number of years to control dampness. But this technique is not efficient and not good for the health as it produces hazardious gases which are harmful for the human health. In this study synthetic polymers were used to control the dampness by improving the water proofing quality of the material. The effect of the polymers on the compressive strength of concrete was also checked by adding these polymers into concrete during concrete mixing. Structural members like wall footing, concrete slab, concrete cubes and septic tank were casted and tested to check the efficiency of synthetic polymer against seepage or leakage of water. The precast concrete slabs were also tested by using these polymers. The crack was produced along the length of the sewerage pipe and also tested for water leakage after applying multiple coats of polymers. It was found that these polymers are equally efficient for water proofing, crack filling and also improving the compressive strength of the concrete. The water absorption of brick and concrete was also tested by applying multiple coats on each side of the brick and concrete cube. These polymers reduced the water absorption of both bricks and concrete to almost zero. So, these polymers are highly recommended to the construction industry to improve the project life, durability, strength and aesthetic.

Key Words: Defects in concrete, Dampness, Water Absorption, Strength Improvement, Crack Filling and Aesthetic.

1. INTRODUCTION

The development of any country highly depends upon the development of construction industry. Construction industry comprises six to nine percent of the gross domestic products of developed countries. Buildings are the most important part of the constructions industry. There are many defects in buildings like structural and temperature cracks, dampness, settlement and failure. These defects produce due to poor quality workmanship. A typical example is water infiltration through some portion of the building structure that is called dampness, which may create an environment for the growth of mold. Most common defect in buildings is the dampness. Dampness is the existence of unsolicited moisture in different members of a buildings, either because of interruption from outside or condensation of water vapors from within the structure. Many techniques are there to control dampness. In this study new waterproofing techniques are introduced using synthetic polymers.

In order to control the dampness bitumen coating is preferred over polymers as some of the polymers are costly and require skilled labor. Conventional techniques of waterproofing are still used in different developing countries. So, there is a need to introduce the new technique to control the dampness that must be equally economical as well as environment friendly. In this study, modern techniques of waterproofing are introduced by using synthetic polymers like crack filler (PP 007), sealer, hyper coating, Concrete mix (PP 500) and PP 50. The polymers are, Acrylic Polymers, Super Absorbent Polymer (SAPs), Epoxy, Dr. Fixit, Kembond K Fix 75, Polypropylene (PP), Polyvinyl Chloride (PVC) and Polystyrene (PS).

Structural defects are those which arises in the structural member of the building to cause these defects is due to poor design, use of poor materials and human errors these defects arise separately or may be some time in combination. Structural defects caused in members of building including beams, columns, retaining wall and slab. Defects in brick work, dampness in old structure and defect in the plaster work are some type of non-structural defects (Kofi Agyekum, 2013). Another study in Malaysia on seven hostel buildings identified some common defects in the buildings. That are the leakages of water, erosion in steel, penetration of rain water and other types of water in the buildings, horizontal cracks in the interior and exterior walls. These all defects need proper maintenance. Buildings need proper waterproofing to stop water from penetration to stop the damages and to protect the health of users of the building from harm (Wahab, 2011). Crakes are caused in many construction materials because it is nature of construction materials to crake after some time. Contraction and expansion take place due to variation in temperature during winter and summer seasons respectively. This contraction and expansion produce cracks in concrete members which allow the water to enter the structural members through these cracks. As walls cover the major area of buildings that is why thermal cracks are more critical in walls. The cracks in wall are produced due to over loading of wall, use of poor material and poor workmanship. The other reason of wall cracks might be settlement of underneath soil (Nurul Nadia Omar Bakri, 2014). Different studies exposed that the defects also effect directly users of the building that is some of defects create health and economical problem for users. So, these defects should have identified first and then remedial measure should use. These defects should deal separately. The focus will be on the dampness which is one of the most damaging defects in buildings (Ogunoh P. E., 2016). Roof leakage accident arises many times due to poor and improper waterproofing system. As they are using bituminous membrane which causes a lot of problem for them because the bonding between roof concrete and bitumen was poor due to these cracks

appears. The water leakage through those cracks produce dampness which damages the building and effects the health of the users of the building (Suffian, 2013).

Dampness sources are classified into four major types are, Mounting dampness, Penetrating dampness, Condensation, Pipe leakages. Minor sources or causes are, not proper drainage system at the building site. Poor orientation of building, Flawed slope of the roof (fat slab), Poor construction. Indications of dampness are dull spots on the building, paint detaching, sometime plaster flaking, growth of Fungi etc. (Kofi Agyekum, 2013).

Buildings should be such that it prevents any kind of water to penetrate through its element. A research was done on six room residential building in which they use three different stages to investigate the dampness. The first one is visual inspection on which they found from the result that interior and exterior walls are damp the symptom they found is dirty spots, sweltering of paint and efflorescence. The second stage is non-destructive test for which they use moisture meter which give the result is that the dampness is very much noticeable. The third and final stage is destructive test in which they found that the dampness in the kitchen and bathroom is due to the pipe leakages and precipitation penetration. From this it is concluded that when there is not proper waterproofing system to each element or where needed this problem will be damage the building and the health of user also. In spatially in residential building if there is not a proper ventilation then the condensation dampness will occur which disturb the health of users. (Agyekum, 2014). Results from the walls test were carried out like on the double side cladding the free twist limited by 75 % and on the single sided cladding free twist restrained only by 13 %. In order to achieve more rigorous demands from the end users there should be a better interaction between timber producers and contractors of structures and building (Kliger, 2006).

Paint was blistered due to the dampness; plaster was damaged and surface efflorescence could be seen on most of the external and internal wall surfaces. Dampness could be seen on the walls having a height of approximately 1200mm in the walls inside the apartment the dampness could easily be seen on the walls of the bedrooms. Partition walls between the bedrooms and the washrooms were showing serious symptoms of Dampness (Kofi Agyekum, 2013).

The effect of dampness and mold is increasing because the bacteria are becoming stronger than previous many years and there is need to improve lifestyle and stop dampness to cause such types of diseases at the end the researcher suggested that indoor dampness and mold problems constitute an important health hazard. And there is a need to prevent dampness and molds production in workplaces and especially in homes to prevent dangerous diseases of asthma and allergy (Maritta S. Jaakkola, 2009).

Indoor dampness and mold problem are universal and major problems for health diseases and structural members which affects the lives of people, their money and resources. The major problem of dampness and mold is health diseases like asthma. These types of issues are very common in countries where temperature remains very low. insufficient maintenance, improper construction work and construction of tight building to conserve energy by ventilation might be the critical factors for the severity of these issues specially in the cold climatic areas and countries. The dampness in residential buildings is significantly dangerous because it increases the chances of asthma specially in the children (Martín Sevilla, 2014). Polymer Modified Cement Impermeable Coating Material: It is a type of sealing material used in construction and engineering work. When the polymer emulsion and the cement mixed with powder are mixed and took on site and applied to the base, the cement is hydrated to form a seal coat. Polymer modified cement impervious coatings are commonly used as reliable and safe

impervious materials because they have the quality of combining polymer flexibility, hardness and tackiness of cement and they do not require the use of an organic solvent or naked flame (Jack J. Fontana, 2005).

A special type of Geo-Polymers has been produced which can be used to increase the strength of structural members and also provide better waterproofing. With the increase in contact angle on Geo-Polymer surface from 21^0 to 22^0, the specimen will float in water causing low water adsorption. This is called surface hydrophobic modification of material. These polymers will improve the different properties of materials like short setting time, significantly high flow rate, improvement in compressive strength, high bond strength through interfacial bonding of particles which can be shown through dense microstructure. These polymers can also repair concrete of rigid pavement or it can also provide protective coatings for concrete for marine structures (Ping Duan, 2016). With the application of these polymers on samples, the reduction of water level adsorption can be achieved around 0.5% within 28 days. These polymers repair the materials and improve the properties like short setting time which is only 24 minutes, significant high flow rate which is around 212 m, high early compressive strength of concrete and also high bond strength of concrete (A. Kamel, 2016).

2. Research methodology

The research is based on the experimental study on the effect of synthetic polymers on strength and dampness of concrete structures. Most effective polymers are, Acrylic modified polymers, and epoxy modified polymers, PP 50, PP30 crack fillers, and crack sealer. These polymers are equally good for improving the strength as well as for improving the resistance against dampness. For water proofing, sealer is a Liquid synthetic polymer used as primary coating. The function of sealer is to seal the pores on the surface of concrete and plastered surface. Crack filler is a solid synthetic polymer made up with cement. It has property to make grout or slurry flexible throughout its life. It is used to fill cracks, gaps between different structural members and expansion joints.
It is manufactured in Pakistan by Pakistan Phthalates Ltd. Company. They are manufacturing and selling it in market also as crack filler PP 007. Concrete mix is a liquid synthetic polymer manufactured by PPL. It is used in concrete as self-leveling agent and for reducing water quantity in concrete. It is also increasing the strength of concrete. Primer is also a liquid synthetic polymer by PPL available in white color used to close pores in plastered surface while painting it. It can also be manufactured of different colors. Hyper is a liquid synthetic polymer by PPL have transparent properties use after Crack filler to make the surface hard like glass and waterproof it. This polymer is many times used in plumbing work in core filling in kitchen, washrooms and in inlet/outlets of water.
Acrylic modified synthetic polymers are also available in liquid form. The use of these synthetic polymers is to increase strength of mortar and concrete by 3 time of its compressive strength. Epoxy modified synthetic polymers are manufactured in liquid form along with epoxy. These are also used in concrete and cement mortar to increase the compressive strength of concrete by 6 times the compressive strength of concrete.
Seven samples are selected including Spread Footing of Wall, R.C.C Slab with R.C.C Parapet Wall, R.C.C pre-cast Slab with Brick Parapet Wall, Septic Tank (Bricks), P.C.C Blocks (for

strength in Compression), P.C.C Blocks (Waterproofing) and Sewerage Pipe. First of all, construction of 3 steps wall footing of 4'x18", 3.75'x13. Polymers are also used for increasing compressive strength of concrete for that purpose 3 cubes were casted at same W/C ratio and mix design for each test and compare the strength of it.

In order to check the effect of three different polymers total nine cubes were casted having three cubes for Acrylic Modified Polymers, three cubes for Epoxy modified polymers and three cubes without edition of any polymers to compare the strength of polymers edition concrete with this one. To check the effect of polymer in water proofing, a cube with normal water to cement ratio was casted and then polymer was applied at its all sides and put it in the pond for one month for water absorption test. These polymers are good in filing the cracks in structures. For this purpose, a major crack was produced in the asbestos cement pipe and then that crack was filled with this polymer to check its effect in crack filling. Water was pored in pipe and kept it for several days to check the leakage of water from crack.

3. Results and Discussion

After the preliminary tests on the materials, concrete mixed design was carried out to prepare the concrete samples. Samples were casted and cured in the pond for further tests. The samples were cured for prescribed 28 days before the application of polymers. Then the samples were tested by using ASTM method of concrete cubes testing procedure. The results are shown in the below table. The table undoubtedly directs that there is a substantial increase in the compressive strength of concrete after the addition of polymer. It means that these polymers are equally good for water proofing and strength improvement. The polymer almost doubled the compressive strength of concrete.

Table 1: Compressive Load Capacity of Cubes

S/N	Normal concrete	Acrylic Modify Polymers	Epoxy Modify Polymers
	KN	KN	KN
1	362	659	860.1
2	349.59	665.78	871
3	342.98	658.35	867.8
Avg. Load	**351.52**	**661.04**	**866.3**

The sample of the cube which was simple of concrete had the compressive strength of maximum load 362 KN, other went to 349 KN and the last one went down on 342 KN. Now when the acrylic modified cubes were tested a big difference was seen in load bearing as the first sample took load up to 659 KN second one took 665 KN load and the last one took 658 KN. Now the last three cubes of epoxy modified cubes were tested and major difference in load bearing could be seen.

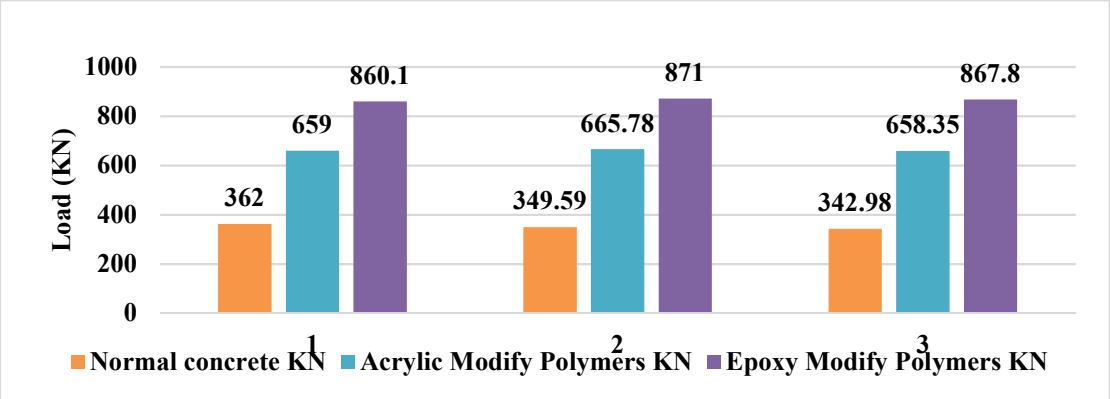


Figure 1: Load Carrying Capacity of Concrete Cubes

Compressive strength of concrete expressed in Psi (pound per square inches), KN/sq.m (kilo newton per mete square) and different other units. As polymers used for waterproofing have dual performance waterproofing as well as strength enhancement. Results shows that acrylic modified polymers and Epoxy modified polymers increase the strength of concrete. Table 2 shows that with the help of synthetic polymers compressive strength will increase.

Table 2: Compressive strength of Cubes with polymers

S/N	Normal concrete	Acrylic Modify Polymer	Epoxy Modify Polymer	Area	KN-lb. factor	Normal concrete	Acrylic Modify Polymer	Epoxy Modify Polymer
	KN	KN	KN	Sq.in	-	Psi	Psi	Psi
1	362	659	860.1	36	224.82	2260.78	4115.62	5371.54
2	349.59	665.78	871	36	224.82	2183.28	4157.96	5439.61
3	342.98	658.35	867.8	36	224.82	2141.99	4111.56	5419.63
Avg.	**351.52**	**661.04**	**866.3**	**Avg. Strength**		**2195.35**	**4128.38**	**5410.26**

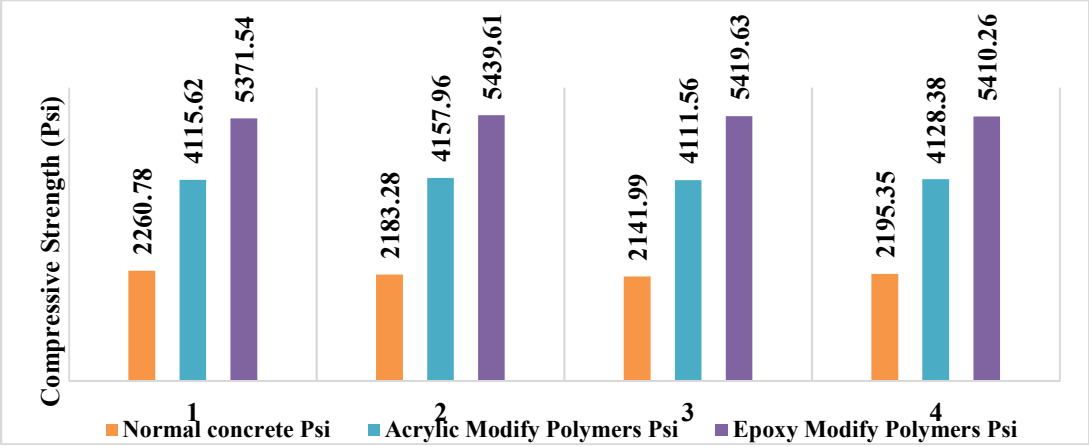
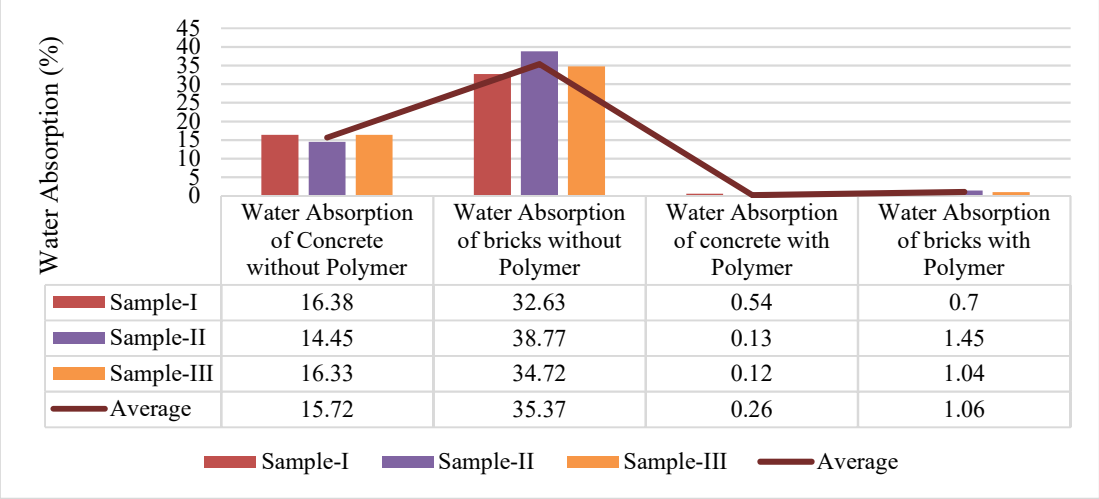


Figure 2: Compressive strength of Cubes with polymers

The compressive strength as well as other properties of the structural members highly depends upon the water absorption power of those members. Amongst all construction material brick have maximum tendency to absorb water. An attempt was made to check the same property of brick but after applying the polymer the water absorption power of brick was significantly reduced to almost zero. After polymers coating bricks do not absorb more water. Results are clear that before polymers coating bricks absorb water more than 35% water and after polymers coating same bricks absorb only 1% water on avg.

Below figure indicated that these polymers are really good in reducing the water absorption of concrete as well as in bricks. These polymers reduced the pores in concrete and bricks that is why water cannot seep through those pores and hence water absorption of material is reduced.



	Water Absorption of Concrete without Polymer	Water Absorption of bricks without Polymer	Water Absorption of concrete with Polymer	Water Absorption of bricks with Polymer
Sample-I	16.38	32.63	0.54	0.7
Sample-II	14.45	38.77	0.13	1.45
Sample-III	16.33	34.72	0.12	1.04
Average	15.72	35.37	0.26	1.06

Figure 3: Water absorption of bricks and concrete with and without Polymer

Similarly, visual inspection was carried out by apply polymers on cast on site concrete slab, asbestos cement pipe and on wall footing. After a month of visual inspection, it was observed that water was not penetrated through the layer of polymer and not a single dampness spot as observed on the surface of these structural members.

4. Conclusions

From the results discussion, it is concluded that the synthetic polymers are the good waterproofing agent that control the seepage and leakage of the water. These synthetic polymers are equally good for the improvement of the compressive strength of concrete as these polymers almost doubled the compressive strength. The water absorption of the material defines its strength. So, the water absorption of structural members can be reduced by using these synthetic polymers. The efficiency of these polymers is equally good for the sewerage pipe where the leakage effects the durability of the pipes. The damp proof course can be improved by applying some coating of synthetic polymers at DPC level.

5. Recommendations

From the results and conclusions, the recommendations are made that Polymers are recommended for the thin walled structures like warehouses and other types of shells because they are prone to cracks, so the use of polymer will improve the strength of these members and also control the cracks. Footing pads is required for the heavy machineries used in any industry. Dampness in the footing pads will cause the rusting of the machine parts. So, application of the polymers will reduce the chance of rusting by improving the waterproofing. For the future studies, the existing building can be used to improve the waterproofing by applying these polymers on the defective areas. Future studied can be done by using other types of polymers like polymer for the insulation.

The other properties of concrete can be studied like durability, weathering and soundness. Polymers should be applied outside where there is direct sun rays or heat so that it should take less time to dry and to complete the desired project on time and to see the full results on the time or schedule. Proper coating should be done there should be no such space remaining on the surface where polymers should be applied if space is remaining it would cause the seepage or dampness which will fail the desired project. Strength will be lesser if dampness is caused as polymers increase the strength also which can be seen in the testing of the polymers on the concrete and the bricks. If the project or samples are made inside the building or any room having stoke or heater type instrument could be used to dry them as would not increase much cost of the project. Cost doesn't very much in using polymers instead of the bitumen or any other materials to stop the seepage. Polymers work 100 % if they are used in the initial stage of the project or construction of any building.

6. References

A. Kamel, M. K. (2016). Evaluation of crack opening performance of a repair material with strain hardening behavior, Cem. Concr. *5*(3), 13-15.

Agyekum, J. A. (2014). A holistic survey of dampness in a six bedroom. *Journal of Science and Technology, 34*(3), 30-45.

Jack J. Fontana, L. J. (2005). Polymer-Modified Concrete. 2-6.

Kliger, P. .. (2006). moisture effects on building and structrual timber. *12*(4), 26-27.

Kofi Agyekum, J. A. (2013). Preliminary Assessment of Dampness in Walls of Residential. *Journal of Sustainable Development, 6*(3), 18-21.

Maritta S. Jaakkola, H. N. (2009). Indoor Dampness and Molds and Development of Adult-Onset Asthma. *5*(3), 7-9.

Martín Sevilla, G. C. (2014). Synthetic polymer waterproofing membrane with self-repair properties. *12*(2), 25-29.

Nurul Nadia Omar Bakri, M. A. (2014). General Building Defects: Causes, Symptoms and Remedial Work. *European Journal of Technology and Design, 3*(3), 12-16.

Ogunoh P. E., N. C. (2016). Building pathology: A tool for resolution of defects in building. *5*.

Ping Duan, C. Y. (2016). A novel waterproof, fast setting and high early strength repair material derived from metakaolin geopolymer. *8*(3), 5-8.

Suffian, A. (2013). Some Common Maintenance Problems and Building Defects. *Procedia Engineering, 54*(1), 101-108.

Wahab, M. H. (2011). A Review Factors Affecting Building Defects of Structural. *Procedia Engineering, 20*(4), 174-179.