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A REVOLUTIONARY PREPACKAGED POLYMER MODIFIED SUPER PLASTICIZED MORTAR WITH FIELD APPLICATION AND ECONOMIC ADVANTAGES

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A Revolutionary Prepackaged Polymer - Modified Superplasticized Mortar With Field Applications and Economic Advantages

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Summary

The prepackaged polymer-modified superplasticized mortar (Hi-Bond) described in this paper is a revolutionary, multifunctional, high-tech, high performance, sustainable, durability improving construction material with a high cost – benefit ratio. Hi-Bond has been developed locally by Dadabhay Construction Technologies (Pvt.) Ltd., (DCTL), Karachi, after extensive studies and research both locally and abroad. It can be used in floorings and pavings, integral waterproofings, adhesive applications, protective and decorative coatings, repairs, renovation, rehabilitation, anticorrosive linings, deck coverings, and durability improvement of canal linings and other hydraulic structures. Hi-Bond has been applied in the projects of national importance with great success including repairs, renovation and rehabilitation of earthquake damaged bridge at Lora Nallah on Brewary Road, Quetta and 200 – year old main dome of the tomb of Hazart Shah Abdul Latif Bhatai, Bhit Shah, Hyderabad. The product was found easy in application and offered numerous advantages in variety of applications at the most economical, cost efficient prices. It is believed that its use in the country including projects in the up country areas will be a technical gift to Pakistan.

Background and Details of Development

Hi-Bond is a revolutionary, multifunctional, high-tech, high performance, sustainable, durability improving constructional material for 21st century and belongs to the category of "Concrete – Polymer Composites" (1). Hi-Bond fulfills the following six principles proposed for durable constructions (2). These include minimize resource consumption (Conserve), maximize resource reuse (Reuse), use renewable or recyclable resources (Renew/Recycle), protect the natural environment (Protect Nature), create a healthy non toxic environment (Non Toxicity), pursue quality in creating the built environment

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(Quality). Hi-Bond is extremely essential for durable construction and is a proportionate mixture of cement, sand, various advanced polymers, superplasticizers, shrinkage reducing and water repelling agents. Only water is required to be added to Hi-Bond before use and hence it is ready to use construction material. Hi-Bond can be used according to need and circumstances in almost every stage of construction, i. e. from foundations to finishing and decoration, in various forms. Extensive studies and research have led to attain the capability to develop such ready-to-use advanced multifunctional constructional materials. It should be borne in mind that for any strong and durable construction, just inorganic binders like cement, lime or gypsum are not sufficient. This is because all these materials are inorganic in nature. Although they do possess the required compressive strength, yet, they have lesser adhesion and hardly any ductility. Nor they have that tortuous system of pores which is very essential for durable constructions. Owing to these deficiencies, repairs using only above mentioned inorganic binders are never durable. Inorganic binders also lack water - proofing qualities. Furthermore, these materials alone can not provide sufficient defense against abnormal or hostile weather conditions including freezing and thawing and exposure to water or earth in case of water retaining structures which are called environmental engineering concrete structures (EECS) as per ACI terminology.

Old structures of ancient times, i.e. "Structures of Pre - Cement Induction Period", which still retain their original beauty were constructed not only with lime / gypsum and stone but also contained elasticity and adhesion improving naturally occurring ingredients (in the shape of rice extract, pulses, animal blood, egg albumen, etc.) resembling those present in Hi-Bond. In fact, there is a long list of such ductility and adhesion improving ingredients which were used in old times in constructions depending on their local availability. Because it was not a technological age, the process of combining these ingredients with inorganic building materials was rather lengthy and time consuming.

In the present era, "cement" is the basic construction material and is used all over the world. It is used in the form of cement mortar (cement + sand + water) and cement concrete (cement + sand + stone + water). Before the details of Hi-Bond are elaborated, a comment on the deficiencies of cement mortar and cement concrete is given which necessitates the use of Hi-Bond alone in pure form or Hi-Bond in combination with cement.

Both cement mortar and cement concrete are prepared with some suitable mix proportions for a particular work. While designing cement mortar and cement concrete mixes, mainly their compressive strength is considered and such cement mortar and cement concrete are generally considered better which have more compressive strength. Different standards are available for guidance in this regard. Now a days, durability of cement mortar and cement concrete is also linked to their compressive strength. This means that cement mortar and cement concrete which posses better compressive strength should also be more durable. But pore characteristics of the system like size of pores, their distribution and inter-connectivity is ignored in mix design considerations. These pores are created in cement mortar and cement concrete due to evaporation of water because of a change in the temperature or due to air entrainment and are not apparently visible. To observe them special methods and equipments are now available. These pores have marked effects on the durability of cement mortar and cement concrete. A few large inter - connected pores may prove more dangerous than numerous separated or discrete small pores. Such large inter - connected pores may provide a direct or untortuous path in cement mortar and cement concrete through which ingress of deteriorating agents such as chloride (cl^-) ions, carbon dioxide (CO_2) gas, etc., is easily possible without any resistance. These deteriorating agents either directly destroy the cement mortar or cement concrete by neutralizing them or corrode the existing reinforcing bars of the system. Corrosion of reinforcing bars then eventually leads to spalling and deterioration of cement concrete. Due to this reason early deterioration of concrete has also been reported (3).

Hence, the system of above mentioned pores plays an important role in determining the durability of cement mortar and cement concrete. It has been established from studies and research that ever mounting acrial and land pollution affects the structures as much as it does to human health and structures begin to show signs of deterioration or disintegration much earlier than their designed life based on strength consideration alone. Therefore durability of cement mortar and cement concrete can not solely be attached to only compressive strength. Hence, other durability - related factors must be taken into account while designing the structures. Nowadays, durable and long-lasting cement mortar or cement concrete is the one which is prepared using minimum possible quantity of water yet having the required slump, has a required compressive strength, is dense and has a tortuous system of separated small pores. For effective repair and rehabilitation works, cement mortar and cement concrete must also have better adhesion and elasticity in addition, Hi-Bond is one such very high quality, high performance, durability improving sustainable construction material and possess all the above mentioned characteristics

required for durable and long lasting construction. A monolithic, effective plastic lining system of polymer films is automatically developed in Hi-Bond upon addition of water which is responsible for its improved behaviour. Figs. 1 & 2 are electron micrographs of unmodified cement mortar and Hi-Bond respectively (4). Fig. 2 explains the formation of polymer films in Hi-Bond which are responsible for great improvements in its mechanical and durability characteristics in comparison to unmodified cement mortar.

Fig.1 In the absence of polymer films, unmodified mortar is of poor quality.

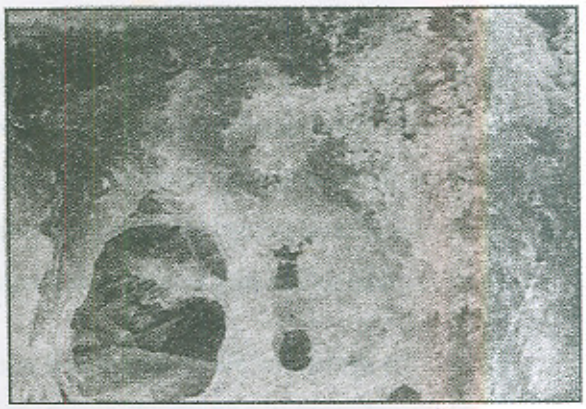
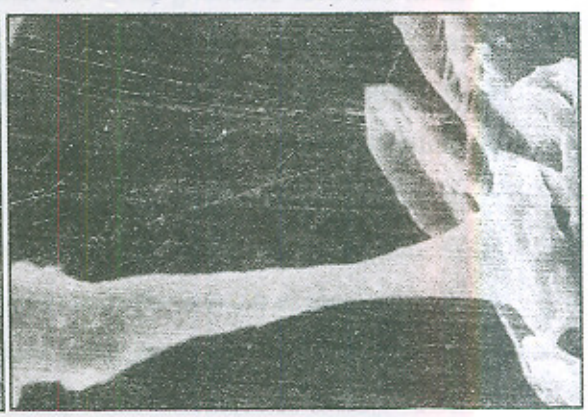


Fig.2 Due to the presence of monolithic network of polymer films in Hi-Bond, its mechanical and durability characteristics are greatly improved in comparison to unmodified mortar. a, b, c, are various appearances of polymer films.

(a)

(b)



(c)

Therefore, an improved cement mortar or cement concrete can be prepared by using Hi-Bond in pure form or by using it as an admixture in a ratio of 3 to 10 percent to the weight of cement in a mix. Addition of upto 10 percent Hi-Bond in a cement mix may

enhance its compressive strength by 25 percent (5, 6) through imaginative use of low water – cement ratio. General characteristics of polymer – modified motors and concretes can be found and compared elsewhere (7, 8, 9). Besides that, different usages of Hi-Bond are enumerated below :-

Applications	Location of Work
Floorings & Pavings	Floors for Houses, Warehouses, Schools, Hospitals, Offices, Shops, Toilets, Passages, Stairs, Gymnasium, Factory, Garages, Railway Platforms, Roads, Airport Runways, etc.
Integral Water Proofings	Concrete Roof - Decks, Mortar Walls, Concrete Block Walls, Water Tanks, Swimming Pools, Septic Tanks, Silos, Brick Canal Lining, etc.
Adhesives	Tile Adhesives, Adhesives for Floorings Walling Materials and Heat - Insulating Materials, Adhesives for Jointing New Cement Concrete or Mortar to Old Cement Concrete or Mortar, etc.
Decorative Coatings (including Surface Preparing Materials)	Wall Coatings, Lightweight Aggregate Coating Materials, Cement Filing Compounds and Self-leveling Cements for Surface Preparation.
Repairing Materials	Grouts for Repairing Cracks and Delaminations of Concrete Structures, Repair of Siphons and Canal Falls and Water Outlets, Patching Materials for Damaged Concrete Structures, Protective Coatings for Corroded Reinforcing Bars, etc.
Anticorrosive Linings	Effluent Drains, Chemical or Machinery Plat Floors, Grouts for Acid - Proof Tiles, Floors for Chemical Laboratories and Pharmaceutical Warehouses, Septic Tanks, Hot Spring Baths, etc.
Deck	Internal and External Ship - Decks, Bridge Covering Decks, Foot Bridge Decks, Train Floors, etc.
Admixture to Mortar & Concrete	For improving the Mechanical and Durability Characteristics of Mortar & Concrete including its use in Canal Linings and other EECS.

Hi-Bond is very easy to use and is available in various forms for various applications. It is applied like any common cement mortar or cement concrete. Curing period is much less than that of ordinary cement mortar or cement concrete when used in pure form. Moreover, comparatively lesser quantity of Hi-Bond is used in comparison to ordinary

cement mortar and cement concrete because thickness of the section can be reduced owing to its higher mechanical characteristics. Hi-Bond is available at highly reasonable prices. Dadabhoy Construction Technologies (Pvt) Limited (DCTL) has developed Hi-Bond in Pakistan. DCTL is the only manufacturer of such type of materials in the country possessing all related patent rights. For information and help of both domestic and international experts about such kind of hi-tech materials, DCTL is making all out efforts. With their help first Pakistan Standard on Concrete - Polymer Composites PS 4035 was established. Rizwan and Kafeel (10) have also worked extensively on the use of other polymers in concrete and these appear to be inferior in performance when compared with Hi-Bond.

Since its launching in 1997, Hi-Bond has not only saved millions of rupees in cash on repairs and rehabilitation works but has also preserved the national heritage (11) and is of consequence to Architects also. In this regard two projects (5, 11) are worth mentioning as an example where Hi-Bond has been used with great success. Brief history of cases regarding such projects in Pakistan are as under:

Rehabilitation of Earthquake Damaged Bridge at Lora Nallah, Brewary Road, Quetta

Piles of the above bridge were cracked due to an earthquake. These piles were restrengthened by filling the cracks with pure Hi-Bond mix. Afterwards, piles were cladded with 8 inch thick Reinforced Cement Concrete (RCC) using 10% Hi-Bond (Universal) as an admixture i.e. 10% Hi-Bond (Universal) to the weight of cement in the mix. Hi-Bond (Universal) bond coats were also applied before each application to ensure better adhesion to old surface. Results of cladding were excellent. The resulting surface was extremely compact and strong. The test cubes of concrete mix using Hi-Bond (Universal) as a 10% admixture showed 25% increase in the compressive strength of concrete at a much lower water-cement ratio. Hi-Bond (Universal) thus proved itself as users friendly requiring minimum skilled labour and highly economical among similar group of materials particularly epoxies, etc (5).

(a)

(b)

(c)

Fig.3 Hi-Bond has been effectively used as an admixture to RCC for cladding and pile strengthening of cracked piles in earthquake damaged Bridge at Lora Nallah, Brewary Road, Quetta. (a) Mixing of Hi-Bond with the mix, (b) Pile strengthening with additional re-bars, (c) Appearance of piles after cladding. (Courtesy: M/s Loya Associates, Karachi)

Repairs and Renovation of the Main Dome at the Tomb of Hazrat Shah Abdul Latif Bhitai, Bhit Shah, District Hyderabad, Sindh.

The above dome was a 200 year old masonry structure consisting of 3 feet wide walls, 26 feet diamater brick masonry set in lime mortar and 16 feet in height. The Dome showed extensive cracking in the outer surface probably due to percolation of rain water inside the walls. Repairs and renovation using ordinary cement mixes were almost impossible due to lesser adhesion and elasticity of the material . Approximate cost for a new replacement was a about Rs.8,000,000/- (Rupees eight lakh only). To save the costs and heritage, it was decided to repair and renovate the dome with Hi-Bond because of its higher adhesion, elasticity and other mechanical and durability characteristics. Outer surface rendering of the dome was removed. Masonry joints were washed properly. Surface was primed using prime coat made with Hi-Bond (Universal). Cement plaster using 7 to 10% Hi-Bond (Universal) as an admixture i.e. 7 to 10% Hi-Bond (Universal) to the weight of cement in the mix, was applied in two coats. Afterwards, 1/8 inch thick

final coat of Hi-Bond (White Color) in pure form was applied to give a permanent white colored water-proof surface. In this way, the whole project was successfully completed in just Rs.310,000/- (Rupees three lakh and ten thousands only), thereby saving millions of rupees. Hi-Bond (Universal) was therefore, proved to be simple to apply, users friendly, highly economical and cost effective among similar group of materials (11).

(a)

(b)

Fig.4 Hi-Bond (Universal) has been successful in preserving the national heritage at 200 - year old Mazar of Shah Abdul Latif Bhitai, Bhit Shah, Hyderabad, Sindh and saved millions of rupees in cash in repairs and renovation works. Hi-Bond (White Color) was used to give a permanent water-proof finish, (a) View of dome during plastering, (b) appearance of dome after completion of the work. (Courtesy: C & W Department, Govt. Of Sindh, Karachi)

Presently Hi-Bond Family of Products consists of :-

a. Hi-Bond
   Prepackaged Polymer - Modified Mortars (Universal)

b. Hi-Bond
   Prepackaged Polymer - Modified Tile Adhesive

c. Hi-Bond
   Prepackaged Polymer - Modified Grey / White Grout
   (Sanded / Unsanded)

d. Hi-Bond
   Prepackaged Polymer - Modified Coloured Grouts
   (Sanded / Unsanded)

e. Hi-Bond
   Prepackaged Polymer - Modified Coloured Plaster

f. Hi-Bond
   Prepackaged Polymer - Modified Coloured Paint Finish

g. Hi-Bond
   Prepackaged Polymer - Modified Coloured Decorative Coatings

Conclusions

Hi-Bond has proved to be users friendly, revolutionary, hi-tech, hi-performance, durability improving, sustainable, multi functional construction material with vary high cost benefit ratio. In the present time of tough economical condition, use of Hi-Bond has become even more important to save enormous labour and material costs in execution of works on one hand and to increase durability of construction on the other hand as well.

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