

A new class of water retention aid based on propoxylated galactomannan in construction application

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ABSTRACT

Galactomannan polysaccharide gum refers to Guar gum and is made by thermochemical treatment of the seed of Cyamopsis tetragonoloba. Propoxylated derivatives of Galactomannan (HPG) are synthesized by the etherification reaction with nonionic propylene oxide reagent with Galactomannan gum. This modification can significantly improve the important properties of unmodified gum like alkaline stability, hydrophobicity, solubility, biostability etc. in context to their application in construction application. The adequate degree of molar substitution in propoxylated derivatives of galactomannan lead to excellent water retention properties which is most important parameter in most of the construction application. The propoxylated derivatives of Galactomannan improve the performance / workability when typically applied in tile adhesives, tile grouts, cement based wall putty, cement / gypsum based plaster, cement based texture plaster, cement / gypsum based crack filler, flooring and leveling compound etc. Due to its excellent thickening efficiency and pseudo plastic rheology behavior, this product helps to improve the sag resistance of plaster/ mortar during the application on vertical wall.

Introduction

THE term water retention aid is initiated because of its potential application in the developing field of construction technology. Modern construction is impossible without modern construction chemicals. The development of modern construction chemicals used for building industry is oriented towards high functionality, productivity and efficiency which increases the requirements to appropriate materials.

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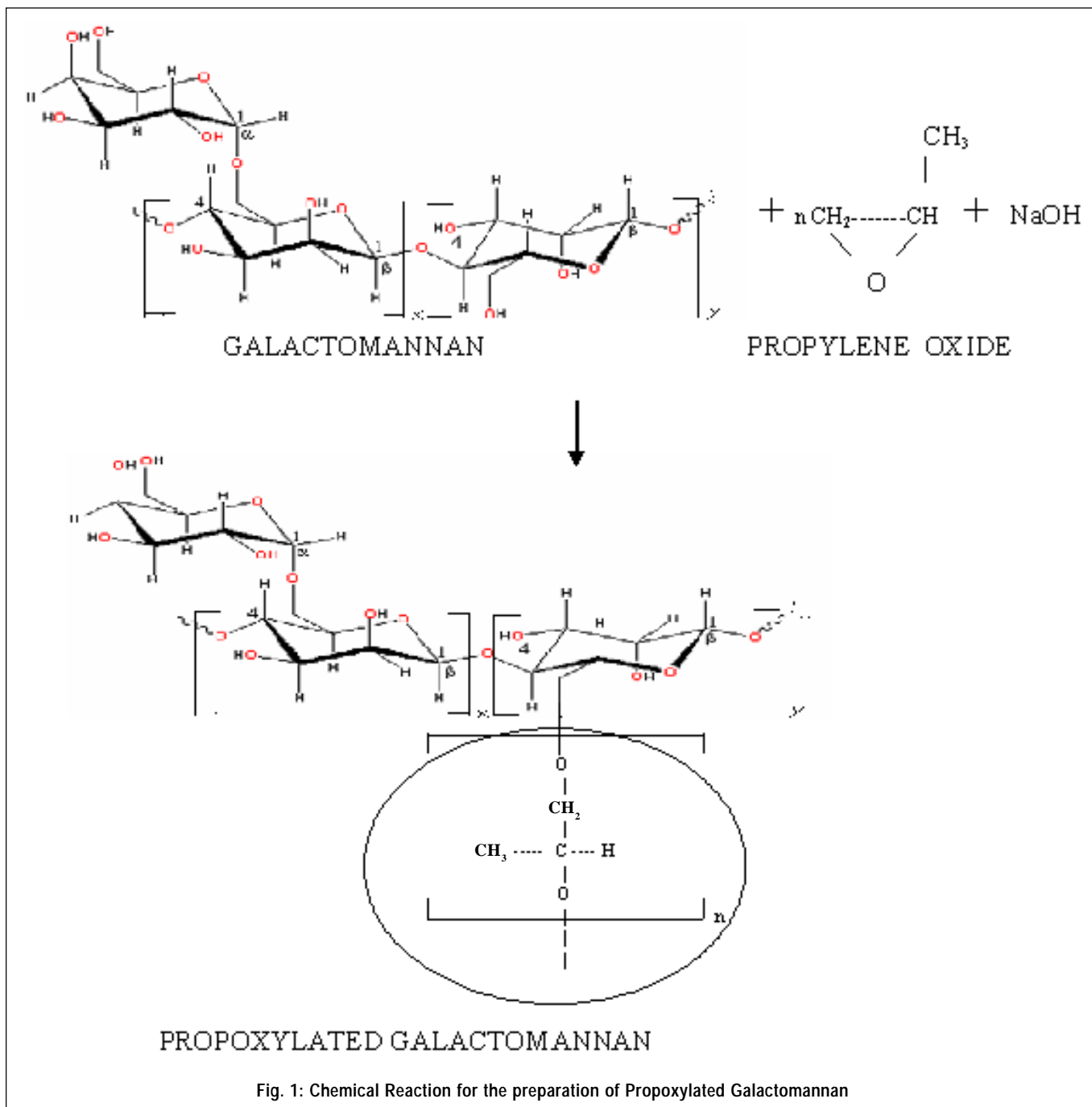
Propoxylated galactomannan

Galactomannan gum (Guargum) is extracted from the seed of the leguminous shrub of Cyamopsis tetragonoloba. Leguminous is cultivated in the semiarid region of tropical countries particular in India/ Pakistan. It is usually found in the form of "splits", that are the endosperms of the seed derived from the husk and from the inner proteinic part i.e. the germ. Galactomannan gum in the form of powder of different particle-size, which is obtained from the splits by milling. The galactomannan consists of a main linear chain of polymannose bearing branches of polygalactose in a molar

ratio of about 2:1. Each ring of the monosaccharide bears three free hydroxyl groups that are for reaction, two of them being in the "cis" position. In *Fig. 1*, the main structure of galactomannan is reported; the mannose units are in the main chain and the galactose units are in the branches.

Propoxylated Galactomannan is prepared by reacting galactomannan gum with non-ionic propylene oxide reagent in presence of alkaline catalyst (sodium hydroxide). The propoxylation reaction may be illustrated by the following equation (*Fig. 1*).

In the parent Galactomannan molecule, there is an average three



hydroxyl (-OH) groups are available for derivatization on D - Mannose or D- Galactose sugar units. There is strong intermolecular hydrogen bonding among the -OH (Hydroxyl Group), themselves and after the propoxylation substitution of the hydroxide group by replacing a part of some hydrogen atoms by - (-CH₂-CH-O)_n

$$\begin{array}{c}
 | \\
 \text{CH}_3
 \end{array}$$

group to separate hydrogen bonding within the molecule. The substitution of hydroxyl group with hydroxypropyl ether linkage that allow side group extension which can lead to some significant and stable changes in properties of parent Galactomannan like increased Hydrophobicity, Enhanced Alkaline stability, Increased Bio stability in context to their application in construction application.

Propoxylated galactomannan as a water retention aid and rheology modifiers

In the present study propoxylated galactomannan (Encotech® CN 4010*) were used as a additives for

* Encotech® CN-4010 is registered trade mark of M/s. encore natural polymers private limited. Encotech® CN-4010 is propoxylated Galactomannan manufactured by M/s. encore natural polymers private limited in PLC operated computerized plant at Ahmedabad, Gujarat, India

Table 1: Properties of Propoxylated Galactomannan (Encotech® CN-4010)

Properties	Result
Chemical Description	Propoxylated Galactomannan
Physical State	Free flow Powder
Color	Creamish to Pale Yellow
Ionic nature	Non-Ionic
Solubility	Soluble in cold and warm water
Moisture Content	10 % Max.
Ash Content	6 % Max.
pH Value (2% solution)	6.0-9.0
Viscosity*	4,000-8,000 cps

* Viscosity of 2.00 % concentration in DI water after stirring at 3000 rpm for 30 minutes and measured after 2 Hrs. by using Brookfield DV III Rheometer/Brookfield RVF viscometer, spindle no.5 and 20 rpm at 20°C.

Water retention aid and Rheology modifier. This propoxylated Galactomannan (Encotech® CN 4010) is specially developed and commercialized by encore natural polymer private limited in their state of the art PLC operated computerized plant. The controlled reaction and adequate degree of propoxylation in Galactomannan molecule leads the product usefulness in verities of construction applications such as tile adhesive, tile grouts, dry cement

based wall putty, cement/ gypsum based plaster, cement / gypsum based crack filler, self leveling and flooring compound etc. to improve the workability of the finished material. Propoxylated Galactomannan helps in water retention characteristics and allows mortar to have longer workability and setting time. Due to its excellent thickening efficiency and pseudoplastic rheology behavior, helps to improve the sag resistance of mortar during the application of vertical wall. *Table 1* shows properties of propoxylated galactomannan.

Characteristic of propoxylated galactomannan in construction application

(A) Water retention

The water retention in most of the building materials is one of the most important parameters. It gives the capability of the mixture to maintain water inside the mortar mixture, by allowing a better setting of the binder and reducing the unpleasant effects of the plastic shrinking. The retention is simply measured as follows:

Test method

Prepared two sets of mortar. One containing Encotech® CN 4010 (Propoxylated Galactomannan) and one blank set i.e. without adding above additive. Place equally weighed small quantity of both the above

mortar mixtures separately on a middle portion of whatman filter paper as shown in *Fig. 2*.

Results: - As indicated in the figure 2, in blank set where Encotech® CN 4010 is not used, the filter paper shokes the water and water migrated from the mortar mixture. In second case in which mortar containing Encotech® CN 4010 additive, the water remaining in mortar for a long time. In this case Propoxylated Galactomannan helps to bind the water and does not allow absorbing the water on the filter paper.

(B) Consistency

The consistency is an important parameter to avoid the plaster sagging and improve the resistance to the tiles sagging when applied on vertical wall.

Test Method

The simple test to determine the consistency and strength of the mortar is as under, Prepared two sets of mortar. One containing Encotech® CN 4010 (Propoxylated Galactomannan) additives and one blank set i.e. without adding above additive.

Results :- The mortar contains the Propoxylated Galactomannan gives good standing and stiff strength on spatula (*See Fig. 3*) where as in blank set without the above additives the mortar mixture straightly runs out from the spatula.



Mortar Mixture with Encotech® CN - 4010 (Propoxylated Galactomannan)

Mortar Mixture without Encotech® CN - 4010 (Propoxylated Galactomannan)

Fig. 2: Water Retention Test



Fig. 3: Consistency Test

(C) Rheology

The water content in mortar mixture act as lubricants for the solid particles when mortar is spread on the surface of the objects to which it is applied. The proper amount of water gives the mixture the "pastiness" or "creaminess" which is suitable for uniform and easy application. This rheological characteristic of the final mixture are very important and it depend on the kind and amount of different ingredients used in the mixture. The simple mixture of cement, sand and water is not suitable for use as a good mortar because of the lack of the above rheological characteristics and also because of its poor processing.

This problem can be overcome by selecting the additives used in the formulation of mortars which act as a both water retention aid and rheology modifier. This additive is propoxylated galactomannan, exhibiting the specific characteristic of bonding and coordinating a large amount of water once they are dissolved in water.

Construction applications

(a) Technology of tile adhesive application

It is well known to use cementitious mortars as adhesives of jointing compositions in the building industry, especially to adhere tiles in both vertically as well as horizontally in different kind of substrates like concrete, bricks or any type of porous as well as non porous surface.

The cementitious mortars generally consist of cement mixed with variable amounts of sand. During the time of use, immediately prior to use, a proper amount of water is

added to the mixture, making it workable.

The curing of such mortar is also commonly referred to as "setting" begins as the mortar is admixed with water and will result in complete hardening and it exhibiting those physical and mechanical features that allow the stable and lasting adhesion of the tile to the surface to which it applied. The hardening of the mortars permits its strong adhesion both to the tile and to the underlying surface.

Many features are important in the setting process, not only the speed of setting influence but also the final effectiveness i.e. solidity. Among these features of fundamental importance are the content of water and the capability of the mortar composition to retain the proper amount of water during the entire setting process. It is important that the mortar retain sufficient water until all the desired physical characteristics are obtained.

There are several potential problems experienced by those installing the tile using the mortar.

- (i) In general the entire surfaces to which tiles are generally applied are porous and highly absorbent. These surfaces absorb water from the mortar in the area of contact, thus defects in the setting which may occur at same point in time resulting the separation of the tile from the surface to which it is attached.
- (ii) Some times tile installers make rapid hardening of the mortar that prevents the adjustment of the tiles during their drying. This problem is called "lack of open time" and/or "lack of adjustability time".
- (iii) When tile installers add excessive amount of water or lack of

homogeneity of the mixing. In these cases, setting becomes too slow due to a loose flowing mixture. If this occurs then the tile tends to slip down by its own weight and resulting application becomes imprecise, more time consuming and difficult.

Important properties of tile adhesive

The ideal cementitious tile mortar may exhibit following different essential properties and their test method and performance with Propoxylated Galactomannan is as under,

(1) Adhesion strength

The adhesion strength is measured using different standard methods such as EN 1348, British Standard, BS: 5890 - 1980

The mortar containing Encotech® CN 4010 shows excellent adhesion strength. The testing of Adhesion strength was done by Nirma Engineering Institute, Ahmedabad, Gujarat, India and test is conducted as per British Standard, BS : 5890 - 1980. The test results for the adhesion strength in the Mortar containing Encotech® CN 4010 are compared against the standard requirement of BS : 5890 - 1980. Please see the detail report mentioned in *Fig. 6*.

Practically it is also observed that the Adhesion strength with Encotech® CN 4010 containing mortar is also possible not only to the porous surface like concrete, bricks etc. but an adequate adhesion is achieved on smooth non porous surface like glazed tiles. Hence tile on tile adhesion is possible with Encotech® CN 4010 additive.

(2) Wet test or open time test

The cementitious mortar is prepared manually and allowed to stand

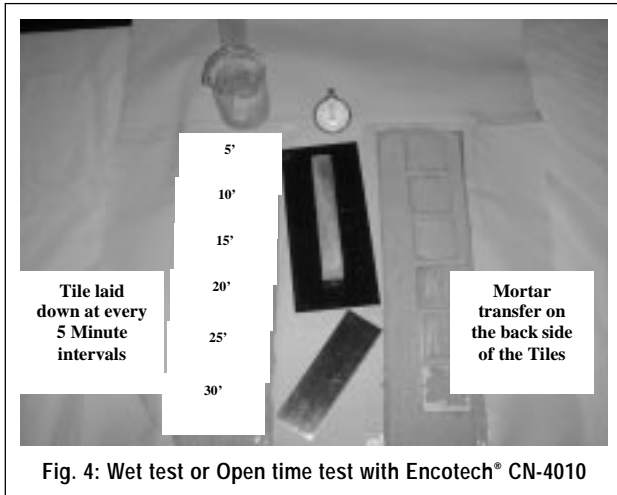


Fig. 4: Wet test or Open time test with Encotech® CN-4010

for 5 minutes and applied after proper mixing to a surface of cement sheet by means of trowels. After every 5 minutes intervals up to 30 minutes ceramic tiles are laid down 50mm X50 mm X 8 mm size; a 2 Kg. of weight is then applied to the tiles for 30 sec.

tile surface covered with mortar on the back of the tile is observed. The results of this test relates to the time elapsed from the application of the mortar which shows the affinity of the mortar with the tiles.

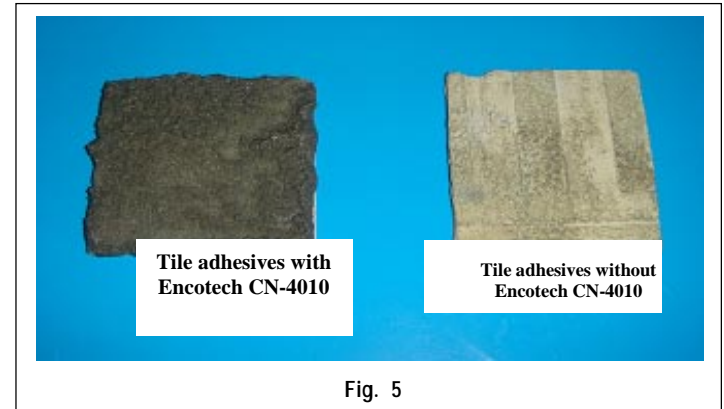


Fig. 5

The tile is pulled off and the area of

Results

It can be seen from the Fig. 4 that the mortar contains propoxylated galactomannan (Encotech® CN 4010) shows that the excellent affinity of the mortar towards back side of the tiles even after 30'. This indicates that Encotech® CN 4010 perform satisfactory open time properties

NIT/CED/CT/MTL/57314/1305 / 1363 / 1405
 July 26, 2005
 27
TEST REPORT (TILE ADHESIVE)

NIRMA
UNIVERSITY

INSTITUTE OF TECHNOLOGY

Client	Encore Natural Polymers Private L
	Plot No. 227/233, Naroda Industrial Estate Ahmedabad
Reference	Letter dated 07-06-2005
Testing amount	Rs.5500/- (Paid)

Formulation Recipe D

- (i) Portland Cement = 35.00%
- (ii) River Sand 0.4 mm = 62.90%
- (iii) Encotech CN 4010 (Hydroxypropyl Guar product of M.S. Encore Natural polymers Pvt. Ltd.) = 0.5%
- (iv) Redispersible polymer powder. Elotex Mp 2050 = 1.60%

- Setting Time – 18 hours
- Tensile Adhesive Strength :

Sr. No	Description	Test Results	BS:5890-1980 (Class AA)
1	14 days under normal laboratory condition	1022 N	Not less than 950 N
2	7 days under normal laboratory condition followed by 7 days immersion in water at laboratory condition	955.50 N	Not less than 560 N

- Shear Adhesive Strength :

Sr. No	Description	Test Results	BS:5890-1980 (Class AA)
1	14 days under normal laboratory condition	12.90 kN	Not less than 8.9 kN
2	7 days under normal laboratory condition followed by 7 days immersion in water at laboratory condition	11.44 kN	Not less than 4.5 kN
3	7 days under normal laboratory condition followed by 7 days storage in oven at a temperature 100 ± 2 °C	16.44 kN	Not less than 4.5 kN

Tested by

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Fig. 6: Test Report of Tile Adhesives

Table 2: Tile Adhesives formulation

Sr.No.	Ingredients	Wt %
1.	Portland Cement	35.0
2.	River Sand (0.2-0.4 mm)	62.9
3.	Propoxylated Galactomannan (Encotech® CN-4010 of M/s encore natural polymers private limited)	0.5
4.	Redispersible Polymer Powder	1.6

Table 3: White Cements Based Wall Putty formulation

Sr.No.	Ingredients	Wt %
1.	White Cement	25-27
2.	Dolomite (400-500 mesh)	45-50
3.	Calcite (400-500 mesh)	10-15
4.	Calcium Carbonate (400-500 mesh)	10-12
5.	Hydroxypropyl Galactomannan (Encotech® CN-4010 of M/s encore natural polymers private limited)	0.6-0.8
5.	Redispersible Polymer Powder	1.8-2.2
6.	Cellulose Fiber	0.1-0.2
7.	Tartaric Acid	0.1-0.2

(3) Comparison of wetting test

Test: Prepared two sets of mortar. One containing Encotech® CN 4010 additive and one blank set i.e. without adding any additives.

Applied the above mortars after proper mixing to a surface of cement sheet by means of trowels. After 15 minutes lay down two 50 mm X 50 mm X 8 mm size of ceramic tiles on both the mortars and 2 Kg. of weight is then applied to both the tiles for 30 sec. After 5 minutes both the tiles are pulled off and the area of tile surface covered with mortar on the back of the tile is observed.

Results: It can be seen from the Fig. 5 that in blank set i.e. without Encotech® CN 4010 there is no transferring of mortar towards back side of the tiles hence poor adhesion strength can result.

The mortar contains Encotech® CN 4010 shows the excellent affinity of the mortar towards back side

of the tiles after 15'. This indicates that Encotech® CN 4010 perform satisfactory open time properties and gives excellent adhesion strength.

(4) An adjustability time

The adjustability time is determined as follows,

The cementitious mortar is prepared manually and allowed to stand for 5 minutes and applied after proper mixing to a surface of cement sheet by means of trowels. The 50 mm X 50 mm X 8 mm sizes of ceramic tiles are laid down and a 2 Kg. of weight is then applied on the tiles for 30 sec.

After 5, 10 and 15 minutes from the application of the mortar one of the tiles is manually rotated to 90 degrees and verifying whether this cause its detachment or not. The adjustability time is reported in minutes and it corresponds to the maximum time at which it is possible to rotate the tile without its detachment from the mortar. Results: - When Encotech® CN 4010 used in Tile adhesive mortar, the tiles are manually rotated up to 90 degree up to 15 minutes from the application of the mortar.

Experimental

Materials

The water retention aid and rheology modifier used in the present study of propoxylated galactomannan (Encotech® CN-4010) used in the preparation of different construction chemicals were from M/s Encore Natural Polymers Private Limited, manufactured in a PLC (programmable logic control) plant at Ahmedabad, Gujarat, INDIA. The other additives pigments, extenders and binders of commercial grades from different sources used in the study without any further modification or purification.

(A) Tile adhesives

In the preparation of tile adhesives was followed in the laboratory to make various experimental sets as per the compositions shown in Table

Table 4: Gypsum Based Plaster formulation

Sr.No.	Ingredients	Wt %
1.	Gypsum	73.5
2.	Calcium Carbonate (400-500 mesh)	24.5
3.	Hydroxypropyl Galactomannan (Encotech® CN-4010 of M/s encore natural polymers private limited)	0.5
4.	Redispersible Polymer Powder	1.5

Table 5: Gypsum Based Crack Fillers formulation

Sr.No.	Ingredients	Wt %
1.	Gypsum	81.5-92.5
2.	Calcium Carbonate (400-500 mesh)	5-15
3.	Hydroxypropyl Galactomannan (Encotech® CN-4010 of M/s encore natural polymers private limited)	0.5
4.	Redispersible Polymer Powder	1.5

Table 6: Tile Grouts formulation

Sr.No.	Ingredients	Wt %
1.	Portland cement	45
2.	Minerals	50-55
3.	Hydroxypropyl Galactomannan (Encotech® CN-4010 of M/s encore natural polymers private limited)	0.5
4.	Redispersible Polymer Powder	1.5

2 for tile Adhesives. In the process, all ingredients are physically mixed in pug mixture.

The testing of tile adhesive was done by well known Nirma Engineering Institute, Ahmedabad, Gujarat and test was conducted as per British Standard, BS: 5890 - 1980 and results are compared against the standard requirement of BS: 5890 - 1980, the test results are shown in Fig. 6.

Other construction applications

Since propoxylated galactomannan give varieties of important characteristic already shown in the study of tile adhesive application, extensive studies with propoxylated galactomannan (Encotech® CN 4010) were carried out in different construction appli-

cations such as dry cement based wall putty, tile grouts, gypsum based plasters, gypsum based crack filler etc. to see its performance.

(I) Dry cement based wall putty

Performance: Good compatibility with different ingredients, Easy dispersibility without lump formation, Excellent water retention and open time, Enhanced workability and good ease of application with knife applicator even in second coat, Outstanding adhesion, Good whiteness index, Smooth finishing etc.

(II) Gypsum based plaster

Performance: Improved setting time property, enhanced open time, outstanding workability with good finishing using hand plaster which thanks to its excellent water reten-

tion power. Satisfactory adhesion and strength etc.

(III) Gypsum based crack fillers

Performance: - Excellent ease of application with knife applicator and provide good smoothness, strength and finishing.

(IV) Tile grouts

Performance: Enhanced flow as well as leveling and finishing, Due to its high open time property it helps in adhesion strength.

Conclusion

The present study reveals that the new class of propoxylated galactomannan additive shows excellent water retention power and also used to maintain the different critical properties such as tensile as well as shear adhesion strength, consistency, rheology, open time, workability etc. These features of propoxylated galactomannan based water retention aid are also beneficial to the different construction application such as dry cement based wall putty, tile grouts, cement / gypsum based plaster, gypsum based crack fillers etc.

Acknowledgement

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