After the equivalent of about 24 hours of continuous operation the felt had become dirty in places and was streaked. Advantage was taken of the fact that it was possible to measure the hardness in places that were obviously clean and obviously dirty. It can be seen that the dirty streaks were somewhat harder than the clean portions of the felt indicating that this may be a useful method to assess the performance of the felt (apart from the usual indications of felt blocking such as water marking etc)

Appendix 3: Water and Solids content of Films on the felt of a Hatschek Machine

Position	Water Content %	Solids Content %
After Tail Drum	52.7%	47.2%
After 1st Top Vacuum Box	49.9%	50.1%
After 2nd Top Vacuum Box	49.0%	51.0%
Sheet after Forming Roll	33.2%	66.8%

SOME EXPERIENCES DURING THE CONVERSION OF HATSCHEK LINE FROM ASBESTOS CORRUGATED PRODUCTS MANUFACTURING TO NON-ASBESTOS TECHNOLOGY AT NAVIFICO

LE HUU THUAN, PHAM MINH TUYEN, PHAM THE DONG

Nam Viet Joint Stock Company (NAVIFICO)
18 F Tang Nhon Phu, Phuoc Long B Ward, District 9, Ho Chi Minh City, Vietnam
Email: naviinfo@navifico-corp.com

ABSTRACT

This article will present some experiences gathered during the project of converting a Hatschek production line from asbestos cement technology to non-asbestos technology at Nam Viet Joint Stock Company (NAVIFICO).
Factors that will be considered during this project include the layout of the current factory, necessary additional equipments, proper mode for new line operating, new formulations, the price of final products and some obstacles in the process of converting technology.

This article will also discuss about the testing results of non-asbestos corrugated products manufactured with different formulations on the same line.

The successful performance of this project has opened the gate to new markets for NAVIFICO since the new non-asbestos products can now meet the requirements of environmental friendly products of both domestic and oversea markets.

KEY WORDS:

Hatschek machine; PVA fibre; FRC;

INTRODUCTION

Asbestos cement roof sheet (AC) has been very popular in many rural, mountainous and coastal areas in Vietnam. From the first factory built in the 1960s, the fibre cement industry has developed up to 41 factories with a capacity of about 106 million m^2 per year providing about 90 million m^2 per year for the roofing market in Vietnam. Most of the lines are small scale with the capacity from 1 - 2.5 million m^2/line per year due to limited amount of investment of the local factories. The larger lines

with the capacity of 5 million m^2/line per year have been in Hanoi, Ho Chi Minh City, Dong Nai Province. AC output has increased from 78 million m^2 in 2005 up to 89 million m^2 in 2013. In the process of product diversification, many joint projects on research and development on non-asbestos technology of which the PVA fibre reinforced composite (FRC) has been selected and NAVIFICO has become one of the first companies producing PVA cement roof sheet (PVA-C) on industrial scale in Vietnam.

THE PROCESS OF CONVERSION

Different from the totally new invested lines, NAVIFICO converted to PVA-C production on the basis of the AC line on the existing factory. The additional machinery include a Hatschek machine and a set of equipment for raw materials treatment stage. Some equipment of the AC line were also modified in accordance with PVA-C technology.

Besides, NAVIFICO has to remove a warehouse to gain an area of 150 m^2 in order to settle the additional equipment for raw materials treatment. This space is quite small, therefore the machinery were design in a compact way by increasing the height of the silos and tanks and installing reverse cycle pumps to disperse the slurry homogeneously.

Figure 1 and Figure 2 show the layout of raw materials treatment area connecting to the mixer, agitator chest and Hatschek sheet machine.

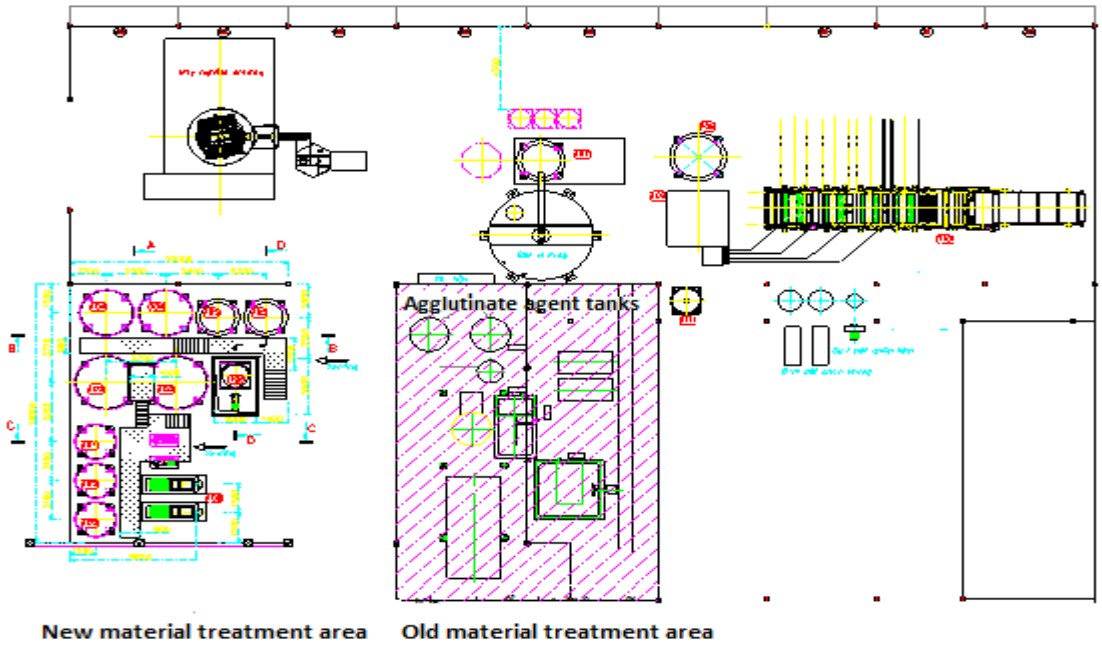

Figure 1 - Layout of raw materials treatment area

Figure 2 - Silos and tanks in the raw materials treatment area

Process flow of PVA-C

Figure 3 below shows the process flow of both corrugated sheets and flat boards. Within this article, we only present the process of PVA-C corrugated sheets.

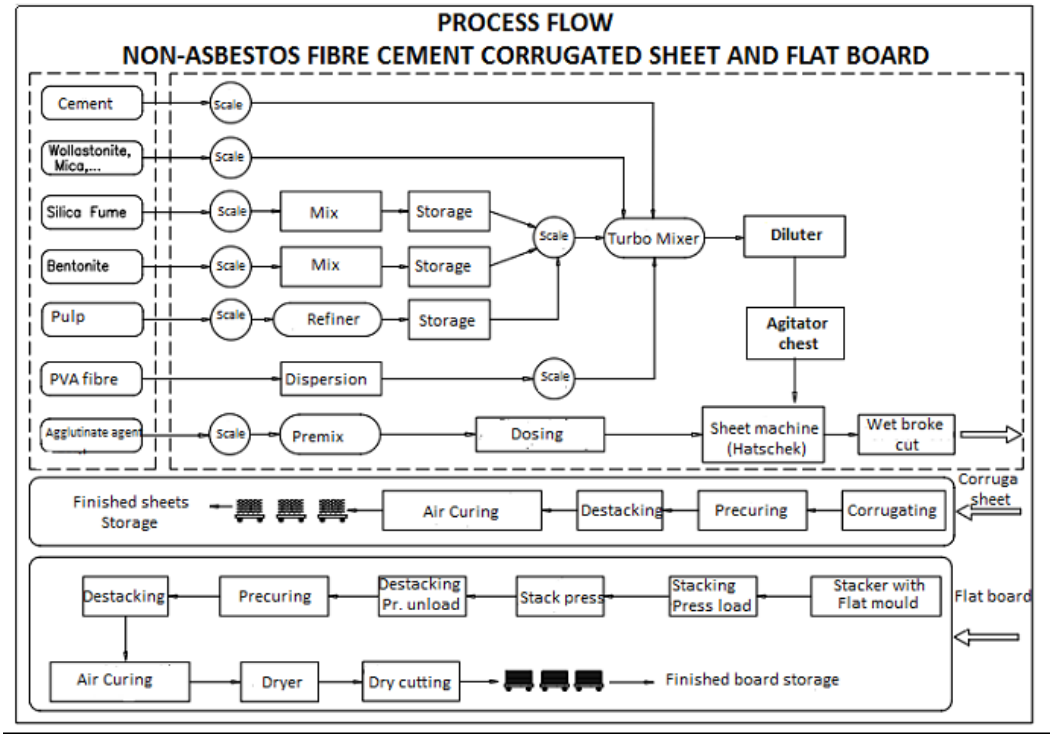

Figure 3 - Process flow of PVA-C roof sheet

The Hatschek process for FRC has been known widely in the fibre cement industry, however, there are differences from AC to PVA-C production mainly at raw material treatment stage. Followings are the short descriptions of un-pressed air-curing PVA-C process flow:

At raw material treatment stage:

- Pulp is disintegrated and refined by hydraulic pulper and refiners then it is transferred to cellulose storage chests with built-in agitators.
- Activated mineral additives including silica fume, bentonite, etc. are mixed with process water and are transferred to storage tanks.
- Pulp and additives slurry are dosed via the batching container with scale and fed into the mixer while it is agitating and the cement and PVA fibre are fed to the mixer.
- When the slurry is homogeneous in the mixer, it is pumped to the diluter where more water is fed to the diluter to a required concentration.
- The diluted slurry is transferred into agitator chest ahead of the sheet machine.
- From this agitator chest, the slurry is fed into the pre-mixer and then to sheet machine.
- Agglutinate agent (flocculant) is also dosed and fed to the sheet machine.

At the Hatschek sheet machine

- In the vat, the slurry dewaters through the mesh of rotating sieve cylinder. While rotating, the fibrous slurry creates thin fibre cement layers on top of the mesh and is pressed to the

machine felt by mean of the couch roll. The felt and fibre cement layer are further dewatered by the vacuum boxes. The forming roll accumulates the layers until the required thickness is reached. The raw sheet is cut off the forming roll and dropped onto a transferred table.

At sheet forming stage

- The raw board is cut to required sizes. The wet broke is disintegrated and dissolved with water and is pumped back to agitator chest.
- The corrugation head moves together and corrugates the raw board to the required profile and put it on the steel mould.

At stacking and pre-curing stage

- The mix stack carriage is transported to the pre-curing tunnel.

At destacking stage

- After pre-curing time, the fibre cement sheets are transported from the mixed stack onto the wooden pallet and moved to the mature store.

At air-curing stage

- The wooden pallets with the destacked sheets are moved to the air-curing area and then to finished sheets storage.

As seen in this process flow, the additional machinery include:

- The cellulose treatment system is upgraded to a higher capacity.
- A new system of activated mineral additives silos and tanks.
- A container for feeding the PVA fibre into the mixer.
- A diluter tank before the agitator chest is added to dilute the slurry to a proper concentration.
- A mixing and dosing tanks of agglutinate agent (flocculant) for sheet machine.
- A newly developed Hatschek sheet machine to replace the old one.

Furthermore, the modifications in the existing line are sensitive adjustments of machinery which result from the differences between the two process technologies as well as the differences between PVA fibre and asbestos fibre in nature.

Figure 4 and Figure 5 show the new Hatschek sheet machine and the destacker at NAVIFICO

Figure 4- Sheet machine (Hatschek) at NAVIFICO

Figure 5- Destacker after pre-curing at NAVIFICO

Invested machinery and equipment in the process of conversion at NAVIFICO

NAVIFICO installed additional machinery and modified the equipment in accordance with the requirements of PVA-C technology. These are include:

- Installing a new clarifying cone to the available 2-cone system ensures the need of process water for mixing materials, diluting slurry and maintaining the slurry level in the sheet machine.
- Fixing new pipeline system separately for producing PVA-C
- Upgrading the pulp treatment machinery providing cellulose which meets the desired fineness and the quantity of pulp.
- Installing new silos and equipment for mixing and storing the activated mineral additives to ensure the slurry is dispersed homogeneously.
- Installing agglutinate agent (flocculant) feeding system ensuring high cement yield and filter performance of the slurry in the sheet machine.
- Investing new 4-vat Hatschek sheet machine with the capacity of 6-8 MT/hour equivalent to 4.7 - 6.3 million m^2/year. The line is design to manufacture corrugated sheets as well as flat boards. The machine is equipped highly automated equipment to control the process parameters, especially the pressure at forming roll, vacuum suction, machine felt speed, agglutinate agent (flocculant) feeder, etc.[1]
- Modifying the wet broke disintegrator system ensuring the rejected boards are dissolved homogeneously.
- Improving cutting system ensuring precise sizes of the final products
- Improving pre-curing tunnel ensuring proper temperature, humidity and time for pre-curing stage.

One of the difficulties in the process is the sensitive characteristic of the technology, so it requires the equipment with highly automated control to all technical parameters and well-trained workers which prevent the defects such as cracks, delamination, fibre balling, etc. that occur in the process. [2]

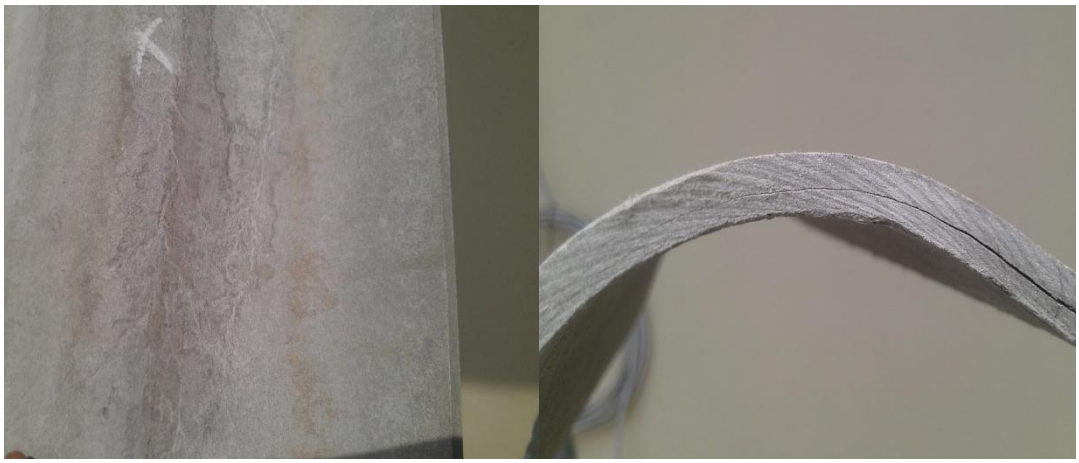

Figure 6- Cracks on the PCA-C sheet **Figure 7- Delamination in the PVA-C sheet**

PRODUCTION ON INDUSTRIAL SCALE

Place and time:

NAVIFICO Fibre Cement Factory, 2013.

Product dimension and profile:

In Vietnam market, most AC roof sheets have the same dimension and profile. This traditional type of roof sheets have been used since the 1960s and are still popular in the roofing market. In order to maintain the sales network in the local market, NAVIFICO has still manufactured the PVA-C products with the same dimension and profile as of AC roof sheets. The characteristics of roof sheets are in accordance to Vietnam Standard TCVN 4434:2000, " Asbestos-cement corrugated sheets- Technical requirements".[3]

As a new product in Vietnam, non-asbestos fibre cement corrugated sheet has not had a standard, therefore the manufacturers have used the asbestos cement corrugated sheet standard which has the same dimension and profile for testing the quality of the PVA-C product. However, a standard for non-asbestos fibre cement flat sheets was issued: TCVN 8258 – 2009 " Fibre-cement flat sheets – Technical requirements".

Characteristics	**Unit**	**Quality criteria TCVN 4434:2000**
Length	mm	1,520
Width	mm	910
Thickness	mm	5
Heigth of corrugation	mm	51
Pitch	mm	177
Number of corrugations	corrugation	5 ½
Break load	N/m	3,500
Density	g/cm^3	1.5
Time of water impermeability	hour	≥ 24

Table 1- Fibre cement roof sheet dimension and profile

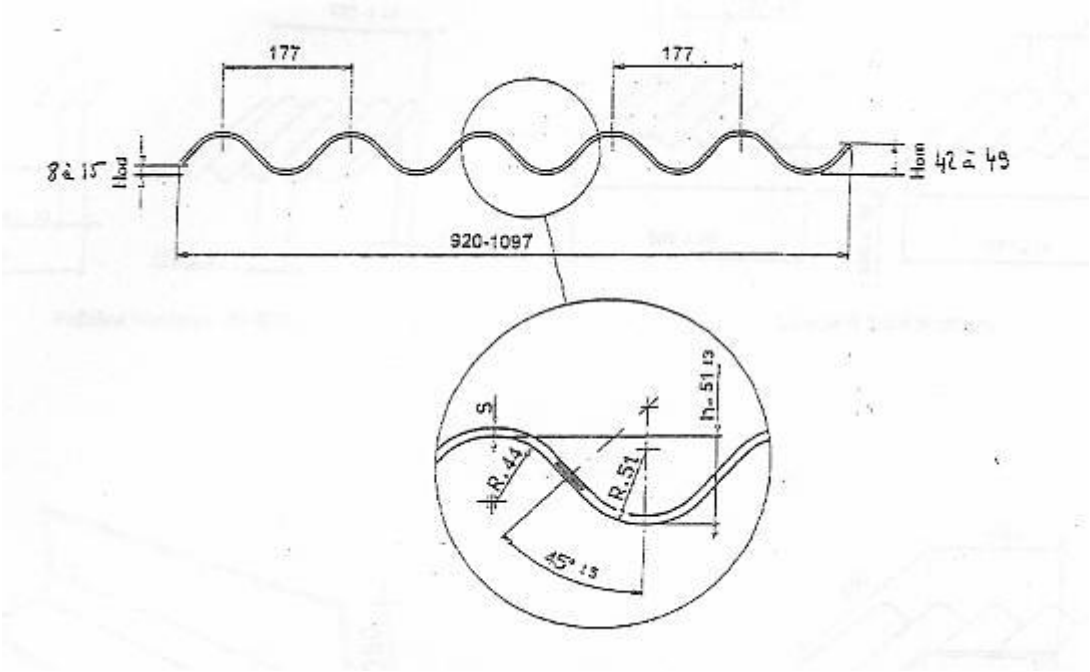

Figure 8: Fibre cement roof sheet corrugation profile

Formulation

Composition	Unit	Formula M1	Formula M2
Kraft pulp	%	2.8 - 3.2	3.3 - 3.7
Kuralon fibre	%	1.4-1.6	1.7-1.9
Activated mineral additives (Silica fume, bentonite,etc.)	%	6 - 7	6 - 7
Portland Cement	%	Remain	Remain
Agglutinate agent (flocculant)	ppm	120-170	120-170

Table 2- Formulas M1and M2 in the production of PVA-C

Two formulas M1 and M2 are selected in the production. The percentages of PVA fibre and Kraft pulp in M2 are higher than that of M1.

Portland cement, activated mineral additives are supplied by local companies. PVA fibre with commercial name Kuralon, delivered by Kuraray of Japan. Silica fume is produced by Elkem of Norway and Kraft pulp is imported from Weyserhaeuser of the USA.

Test results

The full size corrugated sheets specimens of the production are tested in accordance with Vietnam Standard TCVN 4434:2000. The characteristics including Density, Break load and Time of water impermeability of the M1 and M2 are shown in the Table 3 and Table 4 respectively.[4]

Characteristics	**Unit**	**M 1.1**	**M 1.2**	**M 1.3**	**M 1.4**	**TCVN 4434:2000**
Density	g/cm^3	1.53	1.54	1.53		1.5
Break load	N/m	4,750	4,090	4,100		3,500
Time of water impermeability	hour				≥ 24	≥ 24

Table 3 - Mechanical and physical properties of specimen M1

Characteristics	**Unit**	**M 2.1**	**M 2.2**	**M 2.3**	**M 2.4**	**TCVN 4434:2000**
Density	g/cm^3	1.46	1.47	1.49		1.5
Break load	N/m	4,620	4,760	4,810		3,500
Time of water impermeability	hour				≥ 24	≥ 24

Table 4 - Mechanical and physical properties of specimen M2

At the same time, the flat board specimens M1 * and M2 * cut from the flat sheets of the same formulas M1 and M2 are tested the bending strength using three-point bending test in air-dry condition and in accordance with RILEM standard. Test results are shown in Table 5. [5]

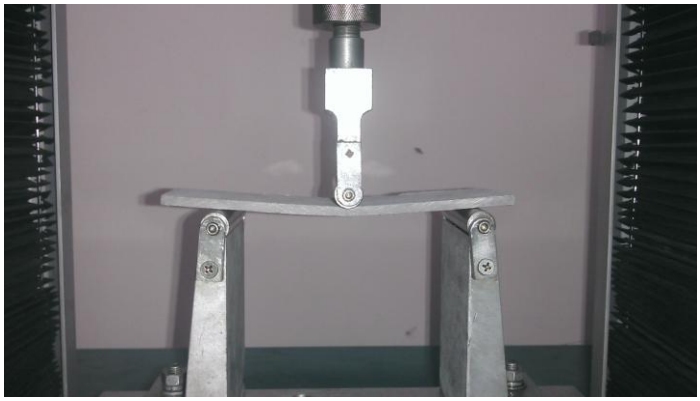

Figure 9 – Testing bending strength of PVA cement sheet

STT	General Information		
1	Specimen name	M1*	M2*
2	Test date	04-01-14	04-01-14
3	Material	FRC	FRC
4	Specimen size [Width*Thickness] (mm)	75*5	75*5.5
5	Specimen section (mm2)	375	412.5
6	Support distance (mm)	135	135
7	Loading force Fpp (kN)	0.200	0.260
8	Stress Rpp (MPa)	22	23
9	Failure energy E (J)	1,257	1,964

Table 5- Mechanical and physical properties of the specimens M1*, M2* flat boards

Figure 10 a and Figure 10 b show the Stress-strain diagram of M1 * and M2 * respectively.

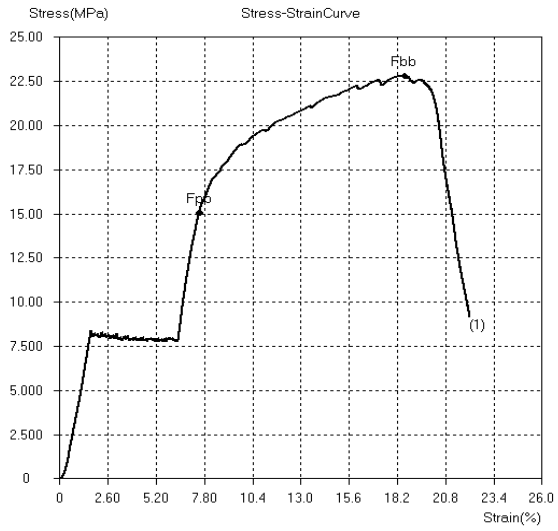

Figure 10 a - M1* Stress - strain diagram

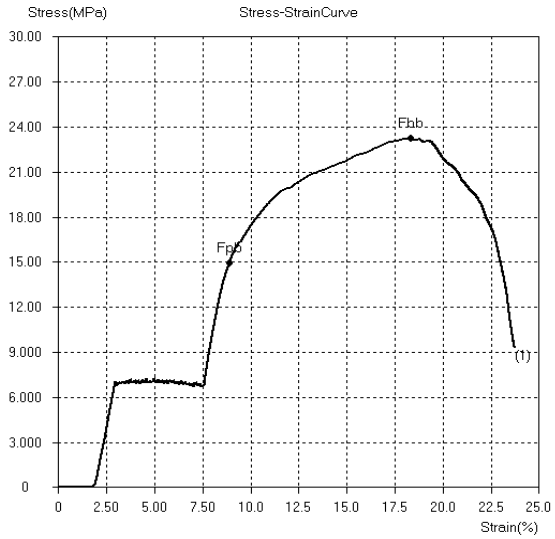

Figure 10 b - M2* Stress - strain diagram

DISCUSSION

- Although the process flow of PVA-C and AC have similarities, however, they are different in term of technology. The PVA-C process flow is more complex and more sensitive than the AC one. It requires a strict control of the process parameters and a new set of raw materials to secure the affinity of PVA fibre to cement based matrix of which result in solving the problem of defects.
- The experiences have shown the important role of the following factors: additional clarifying cone to the available cone system, cellulose treatment, concentration of the slurry, properly feeding the flocculant agent and curing the products.
- As for the test results, referring to the technical requirements of Vietnam Standard TCVN 4434:2000, it requires Break load ≥ 3,500 N/m and Time of water impermeability ≥ 24 hours. Table 3 and Table 4 show that the tested specimens M1 and M2 reach the Standard.
- Referring to technical requirements of Vietnam Standard TCVN 8258 – 2009 " Fibre-cement flat sheets – Technical requirements"[6], it requires Bending strength from 18-22 MPa (Category 5). The Table 5 shows that the tested specimens M1* and M2* reach the Standard.
- The percentages of PVA fibre in the formulas affect the mechanical – physical properties of PVA-C products:
    - Flat specimen M1* having higher percentage of PVA fibre than M2*, obtains higher Bending strength than M2* which has lower PVA fibre percentage as shown in Table 5, Figure 10 a and Figure10 b.
    - Corrugated specimen M1 having higher percentage of PVA fibre than M2, obtains lower density than M2 which has lower PVA fibre percentage as shown in Table 3 and Table 4.

RESEARCH AND DEVELOPMENT OF PVA-C

In 2005, a joint project was cooperated between Vietnam Institute for Building Materials (IBM), ELKEM (Norway) and NAVIFICO to develop non-asbestos cement products and KURARAY, as a Kuralon fibre supplier, advised many useful information on the production process. The product has been used for the housing programme in the coastal mangrove forest in Vinh Chau District, Soc Trang Province and it was also used in sandwich panel walls for residential housing in the Mekong Delta River Region in the South of Vietnam.

Figure 11: PVA roof sheets in Vinh Chau , Soc Trang Province

Figure 12: Sandwich panel walls for housing in Mekong Delta Region

At present, the market of PVA-C in Vietnam has been quite small mainly supplying for the industrial construction projects in domestic market and exporting to oversea market. The PVA-C price is still higher than the AC about 25 percent, therefore NAVIFICO is paying attention in reducing the cost production and trying to penetrate the new PVA-C market in Vietnam.

CONCLUSIONS

The conversion to PVA-C technology is a part of product diversification plan at NAVIFICO and the solution is to convert from the current AC line which is different from totally new investment.

The process flow of PVA-C roof sheet has been determined and it shows the additional machinery and the modification of the existing AC line. The two main set of machinery that have been focused are raw materials treatment equipment and Hatschek sheet machine.

The production layout was rearranged in order to have space for the raw materials treatment area. The equipment are designed in a compact way associating with technical solutions to ensure the circulation of the slurry.

In the process of conversion, NAVIFICO has carried out the cooperation with partners in research and development of FRC and it is really a great support to the Company.

Developing new PVA-C products is a part of product diversification target. It has opened a door for NAVIFICO to the market of PVA-C roof sheets as a light weight, tough and environmental friendly products.

Figure 13 - Exporting PVA-C roof sheets

ACKNOWLEDGEMENTS

We'd like to thank all the experts, colleagues in the Institutions and Companies have supported NAVIFICO in research and development PVA-C products:

RESEARCH INSTITUTE of TECHNOLOGY for MACHINERY (RITM)

KURARAY, DIPRO INTERNATIONAL, ELKEM, WEYERHAEUSER

TAN THUAN CUONG (TTC), BACH DANG JSC, SDC, DMC-SOUTH

REFERENCES

[1] Report on State-level Project: " Developing technology of fabricating Hatschek line to manufacture fibre corrugated and flat sheets", Seminar: Fibre Cement Products – Material, Technology, Machinery and Application, RITM, Hanoi, March 2013.

[2] Do Quoc Quang, Nguyen Dinh Kien, "Hatschek machine and equipment for non-asbestos fiber reinforced cement sheets", Proceedings of International Inorganic-Bonded Fiber Composites Conference, Aalborg, Denmark, September 2010, p. 202-212.

[3] Vietnam Standard TCVN 4434-2000," Asbestos-cement corrugated sheets - Technical requirements", Hanoi.

[4] QUATEST 3, Form No. KT3-4570XD3/2-4 test results, dated 12/27/2013

[5] RITM, Test report NAVI - 2BP1-2 and NAVI - 1BP1-1, dated 01/04/2014

[6] Vietnam Standard TCVN 8258: 2009, "Fiber cement flat sheets - Technical requirements", Hanoi.