

**A PROCESS FOR FORMING A FIBER-CEMENT COMPOSITE SHEET
HAVING SMOOTH-SURFACE AND THE FIBER-CEMENT COMPOSITE
SHEET OBTAINED FROM SAID PROCESS**

Technical Field

5 The present invention relates to the field of engineering, in particular, to a process for forming a fiber-cement composite sheet having smooth-surface and the fiber-cement composite sheet obtained from said process.

Background

10 At present, wood is one of the main materials for construction and it is becoming increasingly scarce, and there is a need to find a material to replace the use of wood. Fiber-cement is an alternative composite material that can be used instead of a real wood. In other words, it is called a synthetic wood. It is made from mixing cementitious material, filler, siliceous material, additive, and fiber together and subjected to fabricate the fiber-cement (e.g. extrusion process, Hatschek process and the likes). The thickness, size, and
15 appearance can be determined according to use. The fiber-cement is used in construction work in structures, fences, walls, rooves, including interiors of buildings. Properties of the composite material used in forming depend on the compositional ratio of the composition, production process, and layer structure of the fiber-cement, which affects the mechanical property of the material, strength, and durability of the product.

20 Fiber-cement can be manufactured using Hatschek process. By this process, the compositions in slurry form are mixed in a mixing tank. Then, the slurry composition is conveyed into a vat having a sieve installed therein. A conveyor belt (for example, felt conveyor belt or similar) rolls through the sieve and forms a wet film from the slurry composition. The film layer is pressed to remove water by a roller installed above the sieve
25 in order to release the film from the sieve onto the surface of the conveyor belt as a fiber-cement composite sheet. The conveyor belt conveys said fiber-cement to the roller for forming a fiber-cement composite sheet at the desired thickness. Then, the fiber-cement composite sheet is cured to set within a predetermined time. The fiber-cement composite sheet obtained from normal Hatschek process provides a strength which is suitable for
30 construction work.

 Apart from the strength of the product, the other preferred character of the fiber-cement composite sheet is a smooth-surface for the ease of further work such as painting,

coating, decorating in order to obtain a clear pattern on the product surface, including printing or laminating work. However, in order to produce smooth-surface fiber-cement composite sheet, special processes are needed, for example, high pressure pressing sanding, polishing or surface rubbing. These special processes reduce the thickness and strength of the product, and also increase the cost because of the extra steps or processes in the production.

Patent publication WO 2002070218 A1 disclosed a fiber reinforced cement (FRC) having improvement of a surface of a fiber-cement composite sheet by producing a coating material for surface properties, including smoothness. Said process comprises the step of:

10 a) providing a slurry composition comprising cement, silica, fiber, and additive in the composition; b) feeding the slurry from a mixing machine into at least 1 vat, wherein each vat is connected to a sieve; c) forming the fiber-cement composite sheet on a roller using Hatschek process; and d) curing. Step c) further comprises a spattered layer before forming on the roller with another slurry composition having different composition in order to

15 improve a surface property of the fiber-cement composite sheet. However, although this document disclosed the forming of the fiber-cement composite sheet by Hatschek process and obtaining the fiber-cement composite sheet with adjusted surface condition, the Hatschek process disclosed in this document only uses one slurry composition in the forming of fiber-cement composite sheet from the sieve then adding the spattered layer

20 with another substance. This is different from the forming of material layer from two slurry compositions via separate sieves which gives different composition that causes different physical properties without the need of the spattered layer. Moreover, said document does not aim to maintain the strength of the obtained fiber-cement composite sheet product and does not propose to use the fiber-cement composite sheet for saving an amount of coating

25 material (e.g. color).

Patent publication US 20180169895 A1 disclosed a forming process of a fiber-cement composite sheet comprising the step of: a) providing a fiber-cement slurry composition containing filler and additive in a mixing tank; b) feeding the slurry composition from the mixing tank to at least 2 vats, each vat being connected to at least 2

30 sieves; c) forming at least 1 layer of fiber-cement on a drum from the slurry composition using Hatschek process; and d) taking the layer of the fiber-cement composite off the drum and curing until completely solid. Each vat has an input pipe and valve for controlling the level of the slurry composition from the mixing tank separately for ease of controlling the

substance level in the vat. However, although said document has the Hatschek process and the separation of vat input, the separation of the slurry composition in each vat only aims for the ease of level controlling the substance. The forming process still uses the same slurry composition. This document does not provide an improvement in the fiber-cement composite sheet in order to provide the desired properties.

Canadian Journal of Civil Engineering (27(3), 543-552) disclosed the forming of a fiber-cement using an auger-type extruder which intended to study physical properties of the obtained fiber-cement. Said extrusion used slurry composition comprising cement, silica, methyl cellulose and either long fiber or short fiber. The study found that the forming of the fiber-cement having only short fiber provided the fiber-cement with smoother surface property than the forming of the fiber-cement having only long fiber. On the other hand, the forming of fiber-cement having only long fiber provided better strength property. Nevertheless, although said document showed the result of the fiber selection that affects the improvement of the fiber-cement, the disclosed process in said document is the forming by a screwed extruder in which the screwed extruder extrudes the slurry composition via the screwed pressure inside the machine causing stress in the material which affects the strength of the internal structure of the obtained fiber-cement. Moreover, the forming by screwed extruder differs from the layer forming process using Hatschek process because of different conditions. That is, the Hatschek process is the forming layer by layer which needs to consider the adhesive strength of each layer. It also needs to consider the volume ratio for forming each layer.

Therefore, this invention aims to develop a Hatschek process of forming fiber-cement composite sheet for forming a fiber-cement composite sheet having smooth-surface layer which saves the amount of coating material and still has a base layer for strength without any further production step.

Summary of the Invention

The present invention relates to a process of forming a fiber-cement composite sheet having smooth-surface which saves the amount of coating material used, where the fiber-cement composite sheet still has the same strength. The process comprises the steps of:

a) providing at least two slurry compositions separately in at least two mixing tanks for forming the fiber-cement composite sheet comprising at least two composite layers, where

- the first slurry composition is used for forming a base layer of the fiber-cement composite sheet;
- a second slurry composition, different from the first slurry composition, used for forming a surface layer of the fiber-cement composite sheet ;

b) separately feeding each slurry composition of step a) from each mixing tank into at least two sieves, wherein each sieve contains one slurry composition;

c) forming the composite layers using Hatschek process by conveying the slurry compositions from each sieve to a roller for forming the base layer, and forming the surface layer; and

d) curing the composite layers until obtaining the fiber-cement composite sheet;

wherein the first slurry composition in step a) comprises:

- a cement material in an amount from 1 to 10 % w/v;
- a siliceous material in an amount from 1 to 10 % w/v;
- a filler in an amount from 0.1 to 10 % w/v;
- a long fiber in an amount from 0.1 to 2 % w/v; and
- a medium up to 100 % w/v;

and wherein the second slurry composition in step a) comprises:

- the cement material in an amount from 1 to 10 % w/v;
- the siliceous material in an amount from 1 to 10 % w/v;
- the filler in an amount from 0.1 to 10 % w/v;
- a short fiber in an amount from 0.005 to 1.5 % w/v; and
- the medium up to 100 % w/v.

Brief Description of the Drawings

Figure 1 shows examples of a) fiber-cement composite sheet formed by a layer of one composite material, b) fiber-cement composite sheet formed by layers of two composite materials according to the exemplary embodiments of the invention, and c) fiber-cement composite sheet formed by layers of two composite materials with an intermediate layer according to the exemplary embodiments of the invention.

Figure 2 shows a diameter, a length of the long fiber and short fiber used in the exemplary embodiments of the invention.

Figure 3 shows a flow chart of process using two slurry compositions according to the exemplary embodiments of the invention (sample A-1, B-1 to B-9, and C-1).

5 **Figure 4** shows a control sample 1, sample B-8, and sample C-1 according to the exemplary embodiments of the invention.

Figure 5 shows a surface of control sample 1 and sample B-8 according to the exemplary embodiments of the invention.

10 **Figure 6** shows a use of the fiber-cement composite sheet of control sample 1 and sample B-8 according to the exemplary embodiments of the invention.

Figure 7 shows an example of the fiber-cement composite sheet containing an additive according to the exemplary embodiments of the invention, where a) contains the additive of pigment and b) contains the additive of adhesive property.

Detailed Description

15 The present invention relates to a process of forming a fiber-cement composite sheet having smooth-surface which saves the amount of coating material used, where the fiber-cement composite sheet still has the same strength.

Definitions

20 Technical terms or scientific terms used herein should be construed according to the context that these terms are used in the present invention and are defined as understood by persons skilled in this art. Said terms do not include other meanings of the technical terms or scientific terms that may be said specifically in other context of this detailed description.

25 Any tools, equipment, methods, or chemicals named herein mean tools, equipment, methods, or chemicals being used commonly by an ordinary person skilled in the art unless expressly stated that they are tools, equipment, methods, or chemicals specific only to this invention.

30 Use of a singular noun or pronoun with “comprising” in claims or specification means “one” but may also refer to “one or more,” “at least one,” and “one or more than one.”

All components and/or methods disclosed and claims in this application aim to cover embodiments from any action, performance, modification, or adjustment without

any experiment that significantly differs from this invention, which would result in creation of an object with the same utility or which would be deemed substantially similar to the present embodiment according to an ordinary person skilled in the art, whether or not such variation is specifically stated in the claims. Therefore, objects that are similar or which
 5 may be substitutable for the present embodiment, including those with minor modifications or adjustments that may be clearly devised by an ordinary person skilled in the art should be construed as being within the spirit, scope, and concept of invention as appeared in the appended claims.

Throughout this application, the term “about” means any number referenced herein
 10 that could be varied or deviated from any error of equipment, method, or person using said equipment or method.

The terms, "coat", “coating”, “coating material”, and/or other similar terms may be interchangeably used and refer to a coating material applied to the surface of fiber-cement composite sheet, where the coating material is selected from color, multiple color, clear
 15 coat, pattern, multiple color pattern, or combination thereof. Additionally, this coating material may either fully coat the surface layer and/or the coating may be applied to at least a portion of the surface layer such that they are not fully coated.

Hereafter, embodiments of the invention are elucidated to show details of the invention by way of explanatory embodiments. The breadth and scope of the present
 20 invention should be defined only in accordance with the claims and their equivalents issuing from this disclosure.

In one embodiment of the invention, a process for forming a fiber-cement composite sheet having smooth-surface, comprising the steps of:

- a) providing at least two slurry compositions separately in at least two mixing tanks
 25 for forming the fiber-cement composite sheet comprising at least two composite layers, where
 - the first slurry composition is used for forming a base layer of the fiber-cement composite sheet;
 - a second slurry composition, different from the first slurry composition,
 30 used for forming a surface layer of the fiber-cement composite sheet ;
- b) separately feeding each slurry composition of step a) from each mixing tank into at least two sieves, wherein each sieve contains one slurry composition;

c) forming the composite layers using Hatschek process by conveying the slurry compositions from each sieve to a roller for forming the base layer, and forming the surface layer; and

d) curing the composite layers until obtaining the fiber-cement composite sheet;

5 wherein the first slurry composition in step a) comprises:

a cement material in an amount from 1 to 10 % w/v;

a siliceous material in an amount from 1 to 10 % w/v;

a filler in an amount from 0.1 to 10 % w/v;

a long fiber in an amount from 0.1 to 2 % w/v; and

10 a medium up to 100 % w/v;

and wherein the second slurry composition in step a) comprises:

the cement material in an amount from 1 to 10 % w/v;

the siliceous material in an amount from 1 to 10 % w/v;

the filler in an amount from 0.1 to 10 % w/v;

15 a short fiber in an amount from 0.005 to 1.5 % w/v; and

the medium up to 100 % w/v.

In another exemplary embodiment of the invention, the second slurry composition further comprises the long fiber in an amount from 0.005 to 1.5 % w/v.

20 In a preferred exemplary embodiment of the invention, the first slurry composition comprises:

the cement material in an amount from 1 to 8 % w/v;

the siliceous material in an amount from 1 to 8 % w/v;

the filler in an amount from 0.3 to 5 % w/v;

the long fiber in an amount from 0.1 to 1.5 % w/v; and

25 the medium up to 100 % w/v.

In a preferred exemplary embodiment of the invention, the second slurry composition comprises:

the cement material in an amount from 1.7 to 7 % w/v;

the siliceous material in an amount from 1.7 to 7 % w/v;

30 the filler in an amount from 0.3 to 2 % w/v;

the long fiber in an amount from 0.15 to 1.1 % w/v;

the short fiber in an amount from 0.01 to 0.2 % w/v; and

the medium up to 100 % w/v.

In another exemplary embodiment of the invention, in step c) the thickness ratio of the base layer to the surface layer is from 1:0.1 to 1:1.

In a preferred exemplary embodiment of the invention, in step c) the thickness ratio of the base layer to the surface layer is from 1:0.4 to 1:0.6.

5 In another exemplary embodiment of the invention, the long fiber is a fiber having an average length from 1.5 to 4 mm.

In a preferred exemplary embodiment of the invention, the long fiber is a fiber having an average diameter from 20 to 40 μm .

10 In another exemplary embodiment of the invention, the short fiber is a fiber having an average length from 0.5 to 1.5 mm.

In a preferred exemplary embodiment of the invention, the short fiber is a fiber having an average diameter from 5 to 15 μm .

In another exemplary embodiment of the invention, the first slurry composition further comprises an additive in an amount from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment, preservative, luminescence, bulking agent, 15 defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor, or mixture thereof.

In another exemplary embodiment of the invention, the second slurry composition further comprises the additive in an amount from 0.1 to 30 % wt of the cement material, 20 where the additive is selected from pigment, preservative, luminescence, bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor.

In another exemplary embodiment of the invention, the step c) can be repeated to increase the thickness of the base layer and the surface layer.

25 In another exemplary embodiment of the invention, said process further comprises the step of forming a coating material on the surface layer, where the amount of the coating material is 1.8 to 2.5 g/cm^2 .

In another exemplary embodiment of the invention, step a) further comprises a step of providing a third slurry composition for forming at least one intermediate layer, where 30 the slurry composition comprising:

the cement material in an amount from 1 to 10 % w/v;

the siliceous material in an amount from 1 to 10 % w/v;

the filler in an amount from 0.5 to 10 % w/v; and

the medium up to 100 % w/v.

In another exemplary embodiment of the invention, the slurry composition for forming the intermediate layer further comprises a fiber in an amount from 0.005 to 1.2% w/v, where the fiber is selected from long fiber, short fiber, recycled fiber, or combination thereof.

In another embodiment of the invention, a smooth-surface fiber-cement composite sheet formed by a process comprising the steps of:

a) providing at least two slurry compositions separately in at least two mixing tanks for forming the fiber-cement composite sheet comprising at least two composite layers, where

- the first slurry composition is used for forming a base layer of the fiber-cement composite sheet;
- a second slurry composition, different from the first slurry composition, used for forming a surface layer of the fiber-cement composite sheet ;

b) separately feeding each slurry composition of step a) from each mixing tank into at least two sieves, wherein each sieve contains one slurry composition;

c) forming the composite layers using Hatschek process by conveying the slurry compositions from each sieve to a roller for forming the base layer, and forming the surface layer; and

d) curing the composite layers until obtaining the fiber-cement composite sheet; wherein the first slurry composition in step a) comprises:

- a cement material in an amount from 1 to 10 % w/v;
- a siliceous material in an amount from 1 to 10 % w/v;
- a filler in an amount from 0.1 to 10 % w/v;
- a long fiber in an amount from 0.1 to 2 % w/v; and
- a medium up to 100 % w/v;

and wherein the second slurry composition in step a) comprises:

- the cement material in an amount from 1 to 10 % w/v;
- the siliceous material in an amount from 1 to 10 % w/v;
- the filler in an amount from 0.1 to 10 % w/v;
- a short fiber in an amount from 0.005 to 1.5 % w/v; and
- the medium up to 100 % w/v.

In another exemplary embodiment of the invention, the second slurry composition further comprises the long fiber in an amount from 0.005 to 1.5 % w/v.

In a preferred exemplary embodiment of the invention, the first slurry composition comprises:

- 5 the cement material in an amount from 1 to 8 % w/v;
- the siliceous material in an amount from 1 to 8 % w/v;
- the filler in an amount from 0.3 to 5 % w/v;
- the long fiber in an amount from 0.1 to 1.5 % w/v; and
- the medium up to 100 % w/v.

10 In a preferred exemplary embodiment of the invention, the second slurry composition comprises:

- the cement material in an amount from 1.7 to 7 % w/v;
- the siliceous material in an amount from 1.7 to 7 % w/v;
- the filler in an amount from 0.3 to 2 % w/v;
- 15 the long fiber in an amount from 0.15 to 1.1 % w/v;
- the short fiber in an amount from 0.01 to 0.2 % w/v; and
- the medium up to 100 % w/v.

In another exemplary embodiment of the invention, the step c) has a thickness ratio of the base layer to the surface layer from 1:0.1 to 1:1.

20 In a preferred exemplary embodiment of the invention, the step c) has a thickness ratio of the base layer to the surface layer from 1:0.4 to 1:0.6.

In another exemplary embodiment of the invention, the long fiber is a fiber having an average length from 1.5 to 4 mm.

25 In a preferred exemplary embodiment of the invention, the long fiber is a fiber having an average diameter from 20 to 40 μm .

In another exemplary embodiment of the invention, the short fiber is a fiber having an average length from 0.5 to 1.5 mm.

In a preferred exemplary embodiment of the invention, the short fiber is a fiber having an average diameter from 5 to 15 μm .

30 In another exemplary embodiment of the invention, the first slurry composition comprises an additive from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment, preservative, luminescence, bulking agent, defoaming agent,

dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor, or mixture thereof.

In another exemplary embodiment of the invention, the second slurry composition comprises the additive from 0.1 to 30 % wt of the cement material, where the additive is
 5 selected from pigment, preservative, luminescence. bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor.

In another exemplary embodiment of the invention, the the step c) can be repeated to increase the thickness of the base layer and the surface layer on the roller.

10 In another exemplary embodiment of the invention, said fiber-cement composite sheet has a roughness from 7 to 13 μm .

In another exemplary embodiment of the invention, the fiber-cement composite sheet further comprises a coating material, where the amount of the coating material is 1.8 to 2.5 g/cm^2 .

15 In another exemplary embodiment of the invention, the forming in step a) further comprises a step of providing a third slurry composition for forming at least one intermediate layer, where the slurry composition comprisesing:

the cement material in an amount from 1 to 10 % w/v;
 the siliceous material in an amount from 1 to 10 % w/v;
 20 the filler in an amount from 0.5 to 10 % w/v; and
 the medium up to 100 % w/v.

In another exemplary embodiment of the invention, the slurry composition for forming the intermediate layer further comprises fiber in an amount from 0.005 to 1.2% w/v, where the fiber is selected from long fiber, short fiber, recycled fiber, or combination
 25 thereof.

It should be understood that examples of the invention described hereinafter have been presented by way of explanatory and exemplary embodiments of the present invention only. Thus, the breadth and scope of the present invention should be defined only in accordance with the claims and their equivalents issuing from this disclosure.

30 Examples of the invention

A process for forming a fiber-cement composite sheet according to an exemplary embodiment of the invention uses a Hatschek process to produce the fiber-cement

composite sheet with smooth-surface while still having high strength. Therefore, it requires development of a process including a slurry composition used for forming each layer of the fiber-cement composite sheet including a base layer and a surface layer as shown in Figure 1. The process according to the present invention can produce a fiber-cement composite sheet having the base layer for providing high strength comparable to conventional fiber-cement composite sheet, while the upper surface layer has a smooth surface without requirement of additional post-process and/or post-treatment.

The development of the slurry compositions for surface layer and/or base layer needs to consider mechanical properties of such layers. This is because fatigue failure of layer can happen from impact force according to fatigue load from external force such as the weight of construction structure. This affects the fatigue of a material which causes breaking. Therefore, in the production of fiber-cement composite sheet to have smooth surface and be capable of tolerating an impact damage, there are several factors to be considered; for example, slurry composition and a thickness ratio of base layer to surface layer, which will be described as follows.

- Since the base layer of the fiber-cement composite sheet is used to receive tension from the force exerted on the fiber-cement composite sheet, the material of the base layer should have flexible property in order to reduce a stiffness and brittleness of the base layer. Long and/or large fibers are used for providing strength and flexibility of the fiber-cement composite sheet in order to withstand impact force, therefore the base layer of this invention is designed to have the thickness more than 50% of total thickness in order to give ample strength for the fiber-cement composite sheet.
- The surface layer of the fiber-cement composite sheet is provided on the base layer. The smoothness of the surface layer according to the exemplary embodiment of the invention can be modified by changing types or adjusting amounts of compositions. For example, the compositions include cement material (selected from, but not limited to, portland cement, hydraulic cement, white portland cement, and black portland cement), siliceous materials (selected from, but not limited to, glass sand, ground sand, river sand, ash, pozzolan, and shale), additives (selected from, but not limited to, calcium carbonate, flying ash, clay, calcium sulfate, and waste obtained from the production of reinforcing material), and fiber (selected from, but not limited to, natural fiber, carbon fiber, fiberglass, and glass fiber). Preferably, the

fiber used for the surface layer is short fiber since the short fiber can improve smoothness of the surface layer and reduce the porousness of the surface when coated with coating material (e.g. color). More smoothness of the surface layer would help reduce the adsorption of the coating material thereon and able to save the amount of coating material used.

Figure 2 shows characteristic of a long fiber and short fiber used in the base layer or the surface layer according to the exemplary embodiment of the invention. The fiber is characterized using a fiber analyzer (Valmet FS5). The long fiber has average length from 1.5 to 4 mm, and diameter from 20 to 40 μm . The long fiber can be obtained from, for example, unbleached crafted paper or sulfite membrane. The short fiber has average length from 0.5 to 1.5 mm, and diameter from 5 to 15 μm . The short fiber can be obtained from, for example, hard wood pulp, and/or broad leaf fiber (e.g. Eucalyptus, Racosperma mangium, Acacia mangium, and Earleaf acacia), and/or recycled fiber (for example waste wood, waste paper pulp, recycled paper pulp, or recycled paper).

The term “average length” of the fiber means to include the mean, median, or mode of the total length of the fiber used in the preparation of the slurry composition for forming the fiber-cement composite sheet. The “average diameter” of fiber means the mean, median, or mode of the total diameter of the fiber used in the preparation of the slurry composition for forming the fiber-cement composite sheet.

In the exemplary embodiment of the invention, the Hatschek process used for forming the fiber-cement composite sheet is shown in Figure 3. Two slurry compositions are used in this process, where a first slurry composition is used for forming the base layer composite material and a second slurry composition is used for forming the surface layer composite material of the fiber-cement composite sheet. The obtained fiber-cement composite sheet has smooth-surface layer that can save the amount of coating material used and has the base layer for strength.

However, the scope of the present invention is not intended to limit to use only two types of slurry compositions for forming the base layer and the surface layer, as shown in the example according to the invention. A person skilled in the art or related fields can use a slurry composition different from the first and second slurry compositions without being construed as significantly different from the detailed description of the present invention. The modification or addition of the number or type of said slurry composition includes but

is not limited to the adjustment of the composition ratio of the short fiber to long fiber in base layer, surface layer, and the adjustment of the thickness of each layer.

Additionally, it is not intended to limit the scope of the present invention to only two layers (base layer and surface layer) as shown in the example. A person skilled in the art or related fields can add intermediate layers using a third slurry composition different from the first and second slurry compositions (as shown in example in Figure 1C). Moreover, a person skilled in the art can also modify the composition ratio of the short fiber to long fiber in base layer, surface layer and/or intermediate layer. The process can also be modified to prepare the intermediate layer and adjust the thickness of each layer without being construed as significantly different from the detailed description of the present invention.

The process according to the present invention comprises the following steps.

Step A: two slurry compositions are separately prepared in the mixing tanks. The slurry compositions is used for forming the base layer and the surface layer of the fiber-cement composite sheet. This step can be divided into 3 following sub-steps.

Preparation of the cement material, siliceous material, and additive

- The cement material, siliceous material, and additive are filled in the storage tanks (such as silos) separately.

Preparation of the fiber

- The long fiber is dispersed in water before being stored in the storage tank for further use as the composition for the base layer and/or surface layer.

- The short fiber is dispersed in water before being stored in the storage tank for further use as the composition for the base layer and/or surface layer.

Preparation of the slurry compositions

- The first slurry composition is prepared by feeding the long fiber (which is dispersed in water obtained from the previous step), the cement material, siliceous material, and additive into the first mixing tank. The obtained slurry composition has the solid content from 5 to 20% w/v. The first slurry composition comprises:

- the cement material in an amount from 1 to 10 % w/v;
- the siliceous material in an amount from 1 to 10 % w/v;
- the filler in an amount from 0.1 to 10 % w/v;
- the long fiber in an amount from 0.1 to 2 % w/v; and
- the medium up to 100 % w/v.

- The second slurry composition is prepared by feeding the short fiber and long fiber, which is dispersed in water obtained from the previous step, with the cement material, siliceous material, and additive in the second mixing tank. The second slurry composition comprises:

- 5 the cement material in an amount from 1 to 10 % w/v;
- the siliceous material in an amount from 1 to 10 % w/v;
- the filler in an amount from 0.1 to 10 % w/v;
- the short fiber in an amount from 0.005 to 1.5 % w/v; and
- the medium up to 100 % w/v.

- 10 Optionally, the second slurry composition may further comprise long fiber in an amount from 0.005 to 1.5 % w/v.

Step B: Each slurry composition obtained from step a) is separately fed from each mixing tank into at least two sieves, wherein each sieve contains one slurry composition.

- The first control unit (not shown in the Figure 3) controls feed of the first slurry composition in the first mixing tank to 1 to 7 sieves for forming into the base layer of the fiber-cement composite sheet. For example, as shown in Figure 3, the first slurry composition is fed into 4 sieves.

- The second control unit (not shown in the Figure 3) controls feed of the second slurry composition in the second mixing tank to 1 to 4 sieves for forming into the surface layer of the fiber-cement composite sheet. For example, as shown in Figure 3, the second slurry composition is fed into 2 sieves.

- The number of sieves used in the process can be adjusted such that the fiber-cement composite sheet with suitable strength surface and smooth-surface is obtained. The number of sieves can be from, but not limited to 2, 4, 6, or 8 sieves, preferably 6 to 8 sieves. The example of the fiber-cement composite sheet obtained from the process according to the exemplary embodiment of the invention is shown in Figure 4. The process uses the 6-sieves Hatschek process in which 4 sieves are for the first slurry composition and 2 sieves are for the second slurry composition.

- Step C:** Each composite layer of the fiber-cement composite sheet is formed using Hatschek process.

This process uses the conveyor belt to roll through the sieves and forms each layer from the slurry composition in each sieve, where water of the layers is reduced by pressure

to form the fiber-cement composite sheet on the surface of the conveyor belt. Then the conveyor belt further transports the fiber-cement composite sheet to the roller.

In this step, for example, the conveyor belt rolls through to 4 sieves of the first slurry composition to form the base layer composite material from the first slurry composition. Then, the conveyor belt further rolls through 2 sieves of the second slurry composition to form the surface layer of the composite material from the second slurry composition. Then, the moisture is removed before being conveyed to the roller.

Moreover, Step C can be repeated, for example, from 1 to 14 cycles in order to increase the thickness of the fiber-cement composite sheet on the roller. Each cycle would increase the thickness (e.g. from 1 to 5 mm) of base layer and surface layer of the fiber-cement composite sheet on the roller so that the thickness of the fiber-cement composite sheet meets the requirements. For example, the thickness ratio of base layer to surface layer may be controlled to be 1:0.1 to 1:1.

Optionally, in Step C, an intermediate layer may be added using a third slurry composition different from the first and second slurry compositions (as shown in Figure 1C) in order to obtain the fiber-cement composite sheet.

For example, the slurry composition for forming into the intermediate layer may comprise the following:

- the cement material in an amount from 1 to 10 % w/v;
- the siliceous material in an amount from 1 to 10 % w/v;
- the filler in an amount from 0.5 to 10 % w/v; and
- the medium up to 100 % w/v.

The slurry composition for forming the intermediate layer may further comprise the long fiber in an amount from 0.005 to 1.2 % w/v, short fiber in an amount from 0.005 to 1.2 % w/v, and the recycled fiber from 0.005 to 1.2 % w/v.

The example of the recycled fiber includes but is not limited to fiber obtained from cardboard box recycling or fiber obtained from newspaper recycling.

Step D: The fiber-cement composite sheet obtained from Step C is cured by air curing technique in a moisture control room at the temperature of 40 to 80 °C, relative moisture 50 to 100 % RH, for 8 to 24 hours. Alternatively, the fiber-cement composite sheet may be cured by air curing followed by steam curing at the pressure of 5 to 15 bars for 8 to 20 hours may be used in order to cure the fiber-cement composite sheet.

Figure 4 shows the fiber-cement composite sheet obtained from the process of the present invention. It can be seen that the obtained fiber-cement composite sheet (sample B-8, sample C-1) has different layers of base layer and surface layer, where the base layer provides mechanical strength of the fiber-cement composite sheet, while the surface layer provides smooth-surface. The surface layer as shown in sample B-8 and sample C-1 may have roughness from 7 to 13 μm (analyzed by laser technique (Gapgun)). When compared with the fiber-cement composite sheet obtained from conventional Hatschek processes (control sample 1), using only one slurry composition, it can be clearly seen that the upper surface of the fiber-cement composite sheet obtained from the process of the present invention is smoother than the upper surface of the fiber-cement composite sheet obtained from conventional Hatschek processes. As shown in Figure 5, scanning electron microscope (SEM) at the magnification about 35 times shows the upper surface of the fiber-cement composite sheet obtained from the process of the present invention has low porosity and low roughness. Moreover, as shown in Figure 6, when the fiber-cement composite sheet obtained from the process of the present invention are used in a construction of panel, the obtained panel has a smooth-surface, which helps significantly reduce amounts of coating material to be used for coating the obtained panel. The amount of coating material to be used is reduced to only 1.8 to 2.5 g/cm^2 when compared to the fiber-cement composite sheet obtained from the conventional Hatschek process that requires amounts of coating material about 2.7 to 3 g/cm^2 . Accordingly, it is possible to reduce the use of coating material by more than 10 %, preferably by more than 20 %, and more preferably by more than 28 %.

In addition, optionally, the first slurry composition or the second slurry composition may further comprise one or more additives in an amount from 0.1 to 30 % wt of the cement material in order to adjust and/or improve properties of the fiber-cement composite sheet. The additive can be selected from, but not limited to, pigment, preservative, luminescence, bulking agent, defoaming agent, dispersant, reinforcing agent, flow rate adjusting agent, flame retardant, adhesive, anti-slip agent, and catalyst or inhibitor, or combination thereof in order to increase the properties according to the purpose of use such as increasing the surface color of the product or increasing the adhesive property as shown in figure 7 without any intention to limit the scope of the invention. However, the additive does not include coating material.

The properties of the fiber-cement composite sheet obtained from the process according to the exemplary embodiment of the invention would be compared to the fiber-cement composite sheet obtained from the conventional Hatschek process using only one slurry composition, where the testing details are as follows.

5 Investigation of mechanical properties of composite sheet and amount of coating material used for coating the composite sheet, from samples having different thickness ratio of base layer to surface layer

10 The effect of the thickness of base layer to surface layer was studied. Samples have the same controlled amounts of cement material, siliceous material, additive, long fiber, short fiber. However, the thickness ratio of base layer to surface layer is varied to be different in order to test the mechanical properties and amount of usage of color, where the result of each sample is shown in Table 1 and Table 2.

15 Control sample 1 and control sample 2 were fiber-cement composite sheet formed by the conventional Hatschek process using one slurry composition. Sample A-1, sample B-1, sample C-1 were fiber-cement composite sheet formed by the process of the exemplary embodiment of the invention using two slurry compositions, wherein:

 - Control sample 1 was obtained from the conventional Hatschek process with one slurry composition having only long fiber. The amount of coating material on control sample 1 and mechanical properties were set as standard reference.

20 - Control sample 2 was obtained from the conventional Hatschek process with one slurry composition having both long fiber and short fiber. The obtained fiber cement composite sheet of control sample 2 could reduce coating material usage by about 23%. However, its mechanical property was brittle because the toughness of the control sample 2 was reduced by 48 %.

25 - Sample A-1, Sample B-1, Sample C-1 were obtained from the process of the exemplary embodiment of the invention using two slurry compositions, having only long fiber for the base layer and only short fiber for the surface layer.

30 From the test result shown in Table 2, sample A-1 (thickness ratio of about 1:0.25) was found to reduce the coating material usage by 20 % and increase the toughness by 28 % when compared with control sample 1. Sample B-1 which has the thickness ratio of base layer to surface layer of about 1:0.49 could reduce the coating material usage by about 21 % and increase the toughness property by 51 % when compared to control sample 1. Moreover, sample C-1 which has the thickness ratio of base layer to surface layer of about

1:1 could reduce the coating material usage by about 22 % and increase the toughness property by 18 %.

Therefore, from said study, it was found that sample B-1 which has the thickness ratio of base layer to surface layer of about 1:0.49 provided the highest toughness and reduced the coating material usage by 21 %.

Table 1: Compositions of samples of the fiber-cement composite sheet

Slurry composition	One-composite material layer		Two-composite material layers					
	Control sample 1	Control sample 2	Sample A-1 (Thickness ratio of base layer to surface layer 1:0.25)		Sample B-1 (Thickness ratio of base layer to surface layer 1:0.49)		Sample C-1 (Thickness ratio of base layer to surface layer 1:1)	
	One layer	One layer	Surface layer	Base layer	Surface layer	Base layer	Surface layer	Base layer
Cement material (%)	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
Siliceous material (%)	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
Additive (%)	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Long fiber (%)	0.6	0.3	-	0.6	-	0.6	-	0.6
Short fiber (%)	-	0.3	0.6	-	0.6	-	0.6	-
Water (%)	90	90	90	90	90	90	90	90

Table 2: Mechanical properties of the fiber-cement composite sheet obtained from samples having different thickness ratio of base layer to surface layer

	Control sample 1	Control sample 2	Sample A-1	Sample B-1	Sample C-1
Modulus of rupture (MOR) (MPa)	12.96	12.9	14.07	14.79	14.75
Modulus of elasticity (MOE) (MPa)	7,728	8,041	7,526	7,613	7,957
Toughness (J/m ²)	4.48	2.33	5.74	6.78	5.31
Coating material usage (g/cm ²)	2.76	2.12	2.20	2.17	2.15
Surface roughness (μm)	15	11	11	11	11

Investigation of mechanical properties of composite sheet and amount of coating material used for coating the composite sheet, from samples having different compositions

The fiber-cement composite sheet with the thickness ratio of base layer to surface layer of about 1:0.49 was used for these studies. The compositions of the cement material, siliceous material, and additive were varied to investigate the mechanical properties and coating material usage. Table 3 and Table 4 show the slurry compositions and the testing results respectively.

Sample B-2, B-3, and B-4 were formed from two slurry compositions according to the process in the exemplary embodiment of the invention. The compositions of cement material, siliceous material, and additive were adjusted for the surface layer. The results show that sample B-2 could reduce the coating material usage by about 11 % when compared with the control sample 1, but the sample B-2 was quite tough and had low stability, which was not suitable for the product that needs high strength such as ceilings and floors.

Sample B-3 could reduce the coating material usage by about 16 % and gave the strength similar to control sample 1. Moreover, sample B-4 could reduce the coating material usage by about 23 % and gave the strength similar to the control sample 1 as well. Therefore, the study found that composition used for sample B-4 can reduce the amount of coating material and also maintain the strength property.

Table 3: Samples having thickness ratio of base layer to surface layer of 1:0.49, where each sample has different composition of cement material, siliceous material, and additive of the surface layer

Slurry composition	One-composite material layer	Two-composite material layers (Thickness ratio of base layer to surface layer 1:0.49)					
	Control sample 1	Sample B-2		Sample B-3		Sample B-4	
	One layer	Surface layer	Base layer	Surface layer	Base layer	Surface layer	Base layer
Cement material (%)	3.9	2.5	3.5	3.5	3.5	4.2	3.5
Siliceous material (%)	3.7	2.5	3.5	3.5	3.5	4.2	3.5
Additive (%)	1.8	4.4	2.5	2.5	2.5	1	2.5
Long Fiber (%)	0.6	-	0.6	-	0.6	-	0.6
Short fiber (%)	-	0.6	-	0.6	-	0.6	-
Water (%)	90	90	90	90	90	90	90

5 Table 4: Testing of fiber-cement from samples having thickness ratio of base layer to surface layer of 1:0.49, where each sample has different composition of cement material, siliceous material, and additive of the surface layer

	Control sample 1	Sample B-2	Sample B-3	Sample B-4
Modulus of rupture (MOR) (MPa)	12.96	12.31	13.60	14.86

Modulus of elasticity (MOE) (MPa)	7,728	5,536	7,319	8,640
Toughness (J/m ²)	4.48	6.48	4.56	4.39
Coating material usage (g/cm ²)	2.76	2.45	2.31	2.12
Surface roughness (μm)	15	13	12	11

Investigation of mechanical properties of composite sheet and amount of coating material used for coating the composite sheet, from samples having different compositions of long fiber and short fiber

This was the study of the effect of the preparation of the composition. The thickness ratio of base layer to surface layer was about 1:0.49. The surface layer was determined to have cement material of 4.2 % w/v, siliceous material of 4.2 % w/v, and additive of 1 % w/v. The composition between long fiber and short fiber was adjusted in order to evaluate the mechanical properties and coating material usage. Table 5 and Table 6 shows the slurry compositions and the test results respectively.

Sample B-5, B-6, B-7, B-8, and comparative sample B-9 were formed from the two slurry compositions according to the process in the exemplary embodiment of the invention. The composition of long fiber and short fiber was adjusted for different smoothness of surface layers. From the results, it was found that sample B-5 could reduce the coating material usage by about 25 % and gave the strength similar to the control sample 1. Sample B-6 could reduce the coating material usage by about 26 % and gave the strength similar to the control sample 1.

Sample B-7 could reduce the coating material usage by about 26 % and gave the strength higher than the control sample 1. Sample B-8 could reduce the coating material usage by about 28 % and gave the strength higher than the control sample 1. However, the results found that comparative sample B-9 could not reduce the coating material usage when compared with control sample 1.

Table 5: Samples having thickness ratio of base layer to surface layer of 1:0.49, where each sample has different compositions of long fiber and short fiber of the surface layer

Slurry composition	Two-composite material layers (Thickness ratio of base layer to surface layer 1:0.49)									
	Sample B-5		Sample B-6		Sample B-7		Sample B-8		Comparative sample B-9	
	Surface layer	Base layer	Surface layer	Base layer	Surface layer	Base layer	Surface layer	Base layer	Surface layer	Base layer
Cement material (%)	4.2	3.5	4.2	3.5	4.2	3.5	4.2	3.5	4.2	3.5
Siliceous material (%)	4.2	3.5	4.2	3.5	4.2	3.5	4.2	3.5	4.2	3.5
Additive (%)	1	2.5	1	2.5	1	2.5	1	2.5	1	2.5
Long Fiber (%)	0.05	0.6	0.2	0.6	0.4	0.6	0.55	0.6	0.6	0.6
Short fiber (%)	0.55	-	0.4	-	0.2	-	0.05	-	-	-
Water (%)	90	90	90	90	90	90	90	90	90	90

Table 6: Testing results of fiber-cement composite sheet from samples having thickness ratio of base layer to surface layer of 1:0.49 having different compositions of long fiber and short fiber of the surface layer

	Control sample 1	Sample B-5	Sample B-6	Sample B-7	Sample B-8	Comparative sample B-9
Modulus of rupture (MOR) (MPa)	12.96	12.8	13.33	14.01	14.65	14.98

Modulus of elasticity (MOE) (MPa)	7,728	7,719	8,247	8,591	8,723	8,823
Toughness (J/m ²)	4.48	4.31	4.63	5.69	5.98	6.02
Coating material usage (g/cm ²)	2.76	2.07	2.05	2.05	1.98	2.71
Surface roughness (μm)	15	10	10	10	8	14

Therefore, from the results above, it was found that fiber-cement composite sheet samples formed by the process according to the exemplary embodiment of the invention could be used in work that needs smooth-surface which also gave same strength compared to the cement sheet according to the control sample, but the fiber-cement composite sheet according to the exemplary embodiment of the invention provided the smoothness of the surface layer and could save coating material usage up to about 28 %.

Although the aspects of said invention disclose the composition, ratio, equipment, part, unit, and system for the forming of the fiber-cement composite sheet, the principle of the modification of the composition, ratio, including equipment and part described and shown in the exemplary embodiment of the invention may able to be quickly applied with the addition of more than 2 slurry compositions, including other similar forms of the fiber-cement composite sheet without significantly departing from the disclosure of the present invention and does not require experimentation or research by persons skilled in the art of related fields.

The principle of the devices and methods, described in the present invention, aims to cover the aspects of the invention that have been performed, operated, modified, or changed any parameters significantly in order to obtain the outcome of the present invention according to the opinions of persons skilled in the art, although the aspects have not been specifically indicated in the claims. Therefore, any replaceable or similar aspects to the aspects of the present invention, including any minor modification or change that

can be clearly seen by persons skilled in this art, should be construed as under the scope, objective, and concept of the invention as shown in the appended claims.

Best Mode or Preferred Embodiment of the Invention

Best mode or preferred embodiment of the invention is as provided in the
5 description of the invention.

Claims

1. A process for forming a fiber-cement composite sheet, comprising the steps of:
 - a) providing at least two slurry compositions separately in at least two mixing tanks for forming the fiber-cement composite sheet comprising at least two composite layers,
 - 5 where
 - the first slurry composition is used for forming a base layer of the fiber-cement composite sheet;
 - a second slurry composition, different from the first slurry composition, used for forming a surface layer of the fiber-cement composite sheet ;
 - 10 b) separately feeding each slurry composition of step a) from each mixing tank into at least two sieves, wherein each sieve contains one slurry composition;
 - c) forming the composite layers using Hatschek process by conveying the slurry compositions from each sieve to a roller for forming the base layer, and forming the surface layer; and
 - 15 d) curing the composite layers until the fiber-cement composite sheet is obtained; wherein the first slurry composition in step a) comprises:
 - a cement material in an amount from 1 to 10 % w/v;
 - a siliceous material in an amount from 1 to 10 % w/v;
 - a filler in an amount from 0.1 to 10 % w/v;
 - 20 a long fiber in an amount from 0.1 to 2 % w/v, wherein the long fiber is a fiber that has an average length from 1.5 to 4 mm and average diameter from 20 to 40 μm ; and
 - a medium up to 100 % w/v;
 - and wherein the second slurry composition in step a) comprises:
 - 25 the cement material in an amount from 1 to 10 % w/v;
 - the siliceous material in an amount from 1 to 10 % w/v;
 - the filler in an amount from 0.1 to 10 % w/v;
 - a short fiber in an amount from 0.005 to 1.5 % w/v, wherein the short fiber is a fiber that has an average length from 0.5 to 1.5 mm and average diameter from
 - 30 5 to 15 μm ; and
 - the medium up to 100 % w/v.

2. The process for forming the fiber-cement composite sheet according to claim 1, wherein the second slurry composition further comprises the long fiber in an amount from 0.005 to 1.5 % w/v.

3. The process for forming the fiber-cement composite sheet according to claim 1,
5 wherein the first slurry composition comprises:

the cement material in an amount from 1 to 8 % w/v;
the siliceous material in an amount from 1 to 8 % w/v;
the filler in an amount from 0.3 to 5 % w/v;
the long fiber in an amount from 0.1 to 1.5 % w/v; and
10 the medium up to 100 % w/v.

4. The process for forming the fiber-cement composite sheet according to claim 2, wherein the second slurry composition comprises:

the cement material in an amount from 1.7 to 7 % w/v;
the siliceous material in an amount from 1.7 to 7 % w/v;
15 the filler in an amount from 0.3 to 2 % w/v;
the long fiber in an amount from 0.15 to 1.1 % w/v;
the short fiber in an amount from 0.01 to 0.2 % w/v; and
the medium up to 100 % w/v.

5. The process for forming the fiber-cement composite sheet according to claim 1,
20 wherein in step c) the thickness ratio of the base layer to the surface layer is from 1:0.1 to 1:1.

6. The process for forming the fiber-cement composite sheet according to claim 5, wherein in step c) the thickness ratio of the base layer to the surface layer is from 1:0.4 to 1:0.6.

7. The process for forming the fiber-cement composite sheet according to claim 1,
25 wherein the first slurry composition further comprises an additive in an amount from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment, preservative, luminescence, bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and
30 catalyst or inhibitor, or mixture thereof.

8. The process for forming the fiber-cement composite sheet according to claim 1, wherein the second slurry composition further comprises the additive in an amount from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment,

preservative, luminescence. bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor.

9. The process for forming the fiber-cement composite sheet according to claim 1,
5 wherein the step c) can be repeated to increase the thickness of the base layer and the surface layer.

10. The process for forming the fiber-cement composite sheet according to claim 1, wherein said process further comprises the step of forming a coating material on the surface layer, where the amount of the coating material is 1.8 to 2.5 g/cm².

10 11. The process for forming the fiber-cement composite sheet according to claim 1, wherein step a) further comprises a step of providing a third slurry composition for forming at least one intermediate layer, where the slurry composition comprises:

the cement material in an amount from 1 to 10 % w/v;
the siliceous material in an amount from 1 to 10 % w/v;
15 the filler in an amount from 0.5 to 10 % w/v; and
the medium up to 100 % w/v.

12. The process for forming the fiber-cement composite sheet according to claim 11, wherein the slurry composition for forming the intermediate layer further comprises a fiber in an amount from 0.005 to 1.2% w/v, where the fiber is selected from long fiber,
20 short fiber, recycled fiber, or combination thereof.

13. A fiber-cement composite sheet formed by a process comprising the steps of:
a) providing at least two slurry compositions separately in at least two mixing tanks for forming the fiber-cement composite sheet comprising at least two composite layers, where

25 – the first slurry composition is used for forming a base layer of the fiber-cement composite sheet;
– a second slurry composition, different from the first slurry composition, is used for forming a surface layer of the fiber-cement composite sheet;
b) separately feeding each slurry composition of step a) from each mixing tank into
30 at least two sieves, wherein each sieve contains one slurry composition;

c) forming the composite layers using Hatschek process by conveying the slurry compositions from each sieve to a roller for forming the base layer, and forming the surface layer; and

d) curing the composite layers until the fiber-cement composite sheet is obtained;

5 wherein the first slurry composition in step a) comprises:

a cement material in an amount from 1 to 10 % w/v;

a siliceous material in an amount from 1 to 10 % w/v;

a filler in an amount from 0.1 to 10 % w/v;

10 a long fiber in an amount from 0.1 to 2 % w/v, wherein the long fiber is a fiber that has an average length from 1.5 to 4 mm and average diameter from 20 to 40 μm ; and

a medium up to 100 % w/v;

and wherein the second slurry composition in step a) comprises:

the cement material in an amount from 1 to 10 % w/v;

15 the siliceous material in an amount from 1 to 10 % w/v;

the filler in an amount from 0.1 to 10 % w/v;

a short fiber in an amount from 0.005 to 1.5 % w/v, wherein the short fiber is a fiber that has an average length from 0.5 to 1.5 mm and average diameter from 5 to 15 μm ; and

20 the medium up to 100 % w/v.

14. The fiber-cement composite sheet according to claim 13, wherein the second slurry composition further comprises the long fiber in an amount from 0.005 to 1.5 % w/v.

15. The fiber-cement composite sheet according to claim 13, wherein the first slurry composition comprises:

25 the cement material in an amount from 1 to 8 % w/v;

the siliceous material in an amount from 1 to 8 % w/v;

the filler in an amount from 0.3 to 5 % w/v;

the long fiber in an amount from 0.1 to 1.5 % w/v; and

the medium up to 100 % w/v.

30 16. The fiber-cement composite sheet according to claim 14, wherein the second slurry composition comprises:

the cement material in an amount from 1.7 to 7 % w/v;

the siliceous material in an amount from 1.7 to 7 % w/v;

the filler in an amount from 0.3 to 2 % w/v;
the long fiber in an amount from 0.15 to 1.1 % w/v;
the short fiber in an amount from 0.01 to 0.2 % w/v; and
the medium up to 100 % w/v.

5 17. The fiber-cement composite sheet according to claim 13, wherein the step c) the thickness ratio of the base layer to the surface layer is from 1:0.1 to 1:1.

18. The fiber-cement composite sheet according to claim 17, wherein the step c) the thickness ratio of the base layer to the surface layer is from 1:0.4 to 1:0.6.

10 19. The fiber-cement composite sheet according to claim 13, wherein the first slurry composition comprises an additive from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment, preservative, luminescence, bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor, or mixture thereof.

15 20. The fiber-cement composite sheet according to claim 13, wherein the second slurry composition comprises the additive from 0.1 to 30 % wt of the cement material, where the additive is selected from pigment, preservative, luminescence, bulking agent, defoaming agent, dispersing agent, reinforcing agent, flow rate adjusting agent, flame resisting agent, adhesive, anti-slip agent, and catalyst or inhibitor.

20 21. The fiber-cement composite sheet according to claim 13, wherein the step c) can be repeated to increase the thickness of the base layer and the surface layer on the roller.

22. The fiber-cement composite sheet according to claim 13, wherein said fiber-cement composite sheet has a roughness from 7 to 13 μm .

25 23. The fiber-cement composite sheet according to claim 13, wherein the fiber-cement composite sheet further comprises a coating material, where the amount of the coating material is 1.8 to 2.5 g/cm^2 .

24. The fiber-cement composite sheet according to claim 13, wherein the forming in step a) further comprises a step of providing a third slurry composition for forming at least one intermediate layer, where the slurry composition comprises:

30 the cement material in an amount from 1 to 10 % w/v;
the siliceous material in an amount from 1 to 10 % w/v;
the filler in an amount from 0.5 to 10 % w/v; and

the medium up to 100 % w/v.

25. The fiber-cement composite sheet according to claim 24, wherein the slurry composition for forming the intermediate layer further comprises fiber in an amount from 0.005 to 1.2% w/v, where the fiber is selected from long fiber, short fiber, recycled fiber,
5 or combination thereof.