

【DESCRIPTION】**【Invention Title】**

APPARATUS FOR REDUCING TEMPERATURE DIFFERENCE IN MASS
CONCRETE USING PIPE COOLING, METHOD FOR REDUCING TEMPERATURE
5 DIFFERENCE IN MASS CONCRETE USING THE APPARATUS, AND MASS
CONCRETE CURED BY THE METHOD

【Technical Field】

The present invention relates to an apparatus for
reducing a temperature difference in mass concrete during a
10 curing process of the mass concrete, a method for reducing a
temperature difference in mass concrete using the apparatus,
and to the mass concrete cured by the method, and more
particularly, to an apparatus for reducing a temperature
difference in mass concrete during a curing process of the
15 mass concrete, a method for reducing a temperature difference
in mass concrete using the apparatus, and to the mass
concrete cured by the method, wherein at least one or more
pipes are disposed inside cast mass concrete (concrete
structure) and hoses having a plurality of holes formed
20 thereon are disposed on the outer surface of the mass
concrete, thereby allowing the interior of the mass concrete
to be cooled and at the same time allowing the outer surface
of the mass concrete to be heated to reduce the temperature
difference from the interior to the outer surface of the mass
25 concrete, and wherein during the intermediate step of the
curing process, the supply of cooling water to the pipes
disposed inside the mass concrete stops and heated water is
supplied through supply pipes to the outer surface of the
mass concrete, thereby more efficiently reducing the
30 temperature difference from the interior to the outer surface
of the mass concrete.

【Background Art】

Concrete is a composite construction material composed primarily of cement, sand, gravel and water, which is well resistant to natural damages due to water, fires, earthquakes, and so on.

5 The concrete is made in a batch plant and conveyed by a concrete conveyor commonly called a truck mixer. Next, the concrete is cast, hardened and cured to a concrete structure. Through the batch plant, an amount of concrete mixed one time is measured and poured to a concrete mixer, and after the
10 completely mixed concrete is discharged from the concrete mixer, next mixing is performed.

 The cast concrete accompanies hydration reaction when cured. The hydration reaction occurs wherein solute molecules or ions attract water molecules therearound to form
15 a molecule group, and in the process for forming the molecule group, hydration heat is generated.

 The hydration heat increases the internal temperature of the mass concrete to cause a high temperature difference from the interior to the outer surface of the mass concrete,
20 which undesirably temperature cracks. The temperature cracks necessarily occur during a curing process, which is caused by the temperature difference of more than 30°C. In addition to the temperature cracks caused by the temperature difference from the interior to the outer surface of the mass concrete,
25 the shrinkage cracks are generated when the outer surface of the mass concrete is dried during the curing process.

 FIG.1a is a graph showing the outer surface temperature of mass concrete, the internal temperature thereof and the difference between the two temperatures during curing of
30 poured concrete. About 12 days to 15 days are needed until the curing is completed. The internal temperature of the mass concrete is increased to about 90°C by the generation of

hydration heat, and a maximum temperature difference from the interior to the outer surface of the mass concrete is more than about 60°C. Accordingly, the mass concrete cured with the high temperature difference has serious cracks.

5 Especially, during hot summer days where the temperature of external air is substantially high, the hydration heat is also increased, thereby making temperature cracks occur on the mass concrete more seriously. To decrease the temperature cracks in this industrial field, various plans in
10 materials, construction and structures of the concrete have been proposed and utilized, and as the plan in the construction of the concrete during hot summer days, more particularly, pre-cooling through ice plant and pipe cooling are introduced. Alternatively, pipes are installed at the
15 outside of mass concrete to inject water to the outer surface of the mass concrete, thereby making the outer surface of the mass concrete wet.

The pre-cooling is carried out by submerging sand or gravel into ice water and mixing the sand or gravel with
20 cement, and alternatively carried out by spraying cooling water to aggregate or sand. The pipe cooling is carried out by disposing equally spaced pipes in the interior of the mass concrete, by casting concrete, and by curing the concrete, while cooling water is being circulated to the pipes, thereby
25 lowering the internal temperature of the mass concrete.

FIG.1b is a schematic view showing a conventional apparatus for reducing cracks caused by dry shrinkage by injecting water into the outer surface of mass concrete through pipes. As shown in FIG.1b, water is discharged from
30 pipes 30 to make the outer surface 20 of mass concrete 10 wet, thereby preventing the dry shrinkage cracks generated during the drying process of the mass concrete. In this case, the

dry shrinkage cracks are reduced, but the temperature cracks generated by the temperature difference from the interior to the outer surface of the mass concrete still exist.

Further, FIG.1c is a schematic view showing another conventional apparatus for reducing a temperature difference in mass concrete, through pipe cooling. As shown in FIG.1c, cooling water 60 is stored into a water reservoir 100 and supplied to pipes 30 disposed inside mass concrete 10 by means of pumps (not shown). Accordingly, the cooling water 60 flows inside the mass concrete 10 to make the interior of the mass concrete 10 cooled. As a result, the temperature difference from the interior to the outer surface 20 of the mass concrete 10 is reduced.

In conclusion, however, the pre-cooling method has some problems that the ice plant facilities are not easy, the operating cost is raised, and the temperature control is not accurately carried out, and if only the pipe-cooling method is adopted, only the temperature of the interior of the mass concrete is lowered, thereby failing to reduce a temperature difference from the interior to the outer surface of the mass concrete.

【Disclosure】

【Technical Problem】

Accordingly, the present invention has been made in view of the above-mentioned problems occurring in the prior art, and it is an object of the present invention to provide an apparatus and method for reducing a temperature difference from the interior to the outer surface of mass concrete, which reduces the installation cost through simple construction, performs accurate temperature control, and provides high constructability.

It is another object of the present invention to provide an apparatus and method for reducing a temperature difference from the interior to the outer surface of mass concrete, wherein hoses each having a plurality of holes formed on the
5 outer periphery thereof, through which heated water is discharged by means of gravity, with no separate drive power, are disposed on the outer surface of the mass concrete to heat the outer surface of the mass concrete, and at the same time, cooling water flows along pipes disposed inside the
10 mass concrete, so that a curing process is completed, while the temperature difference from the interior to the outer surface of the mass concrete is being reduced.

It is yet another object of the present invention to provide an apparatus and method for reducing a temperature
15 difference from the interior to the outer surface of mass concrete, wherein if the temperature of the interior of the mass concrete is less than a set temperature (for example, about 50°C) in the intermediate step of the curing process, the supplied cooling water is not heated anymore to make the
20 outer surface of the mass concrete not heated efficiently, so that switching valves are operated to supply the heated water to the outer surface of the mass concrete, thereby efficiently reducing the temperature difference.

It is yet still another object of the present invention
25 to provide an apparatus and method for reducing a temperature difference from the interior to the outer surface of mass concrete, wherein heated water is discharged through the holes formed on hoses, a curing blanket is covered on the whole outer surface of the mass concrete, and a heat-
30 retaining member is covered on the curing blanket, which effectively heats the whole outer surface of the mass concrete.

【Technical Solution】

To accomplish the above objects, according to a first aspect of the present invention, there is provided an apparatus for reducing a temperature difference generated in mass concrete made by assembling iron bars, setting up a form and pouring concrete into the form, during a curing process of the mass concrete, the apparatus including: a main water reservoir adapted to store cooling water thereinto; pipes disposed inside the form in such a manner as to be buried in the interior of the mass concrete at the time of concrete casting, the pipes being spaced apart from each other by a given distance in such a manner as to be passed through the mass concrete and being connected to the main water reservoir from which the cooling water is supplied thereto, so that the temperature of the interior of the mass concrete is decreased and the cooling water supplied thereto is heated to discharge heated cooling water therefrom; hoses disposed on the outer surface of the mass concrete in such a manner as to be connected to the output ends of the pipes from which the heated cooling water is supplied thereto, each hose having a plurality of holes formed on the outer periphery thereof, through which the heated cooling water is discharged; an auxiliary water reservoir adapted to store heated water thereinto; supply pipes connected to the auxiliary water reservoir to supply the heated water to the outer surface of the mass concrete if the temperature of the interior of the mass concrete is less than a set temperature; and a control unit operated to supply the cooling water from the main water reservoir to the pipes if the temperature of the interior of the mass concrete is more than the set temperature and to supply the heated water from the auxiliary water reservoir to

the supply pipes if the temperature of the interior of the mass concrete is less than the set temperature.

According to the present invention, desirably, the apparatus further includes switching valves mounted at
5 positions where the output ends of the supply pipes are disposed between the pipes and the hoses to shut off the supply of the cooling water, while supplying the heated water to the hoses through the supply pipes, if the temperature of the interior of the mass concrete is less than the set
10 temperature.

According to the present invention, desirably, so as to collect the heated cooling water or the heated water flowing along the outer surface of the mass concrete through the discharging from the plurality of holes of the hoses disposed
15 on the outer surface of the mass concrete, the apparatus further includes: water recovery ducts disposed along the edges of the mass concrete; and water recovery pipes connected to the water recovery ducts to collect the heated cooling water or the heated water to the main water reservoir,
20 alternatively, further includes: water passages formed along the edges where the mass concrete and the ground meet each other to collect the heated cooling water or the heated water thereto; and water recovery pipes connected to the water passages to collect the heated cooling water or the heated
25 water to the main water reservoir, and alternatively, further includes: water recovery pipes adapted to connect a position where the heated water or the heated cooling water gathers to the main water reservoir; and water recovery pumps provided to collect the heated water or the heated cooling water to
30 the main water reservoir through the water recovery pipes.

According to the present invention, desirably, the apparatus further includes: first pumps disposed between the

main water reservoir and the pipes to supply the cooling water to the pipes; and second pumps disposed between the auxiliary water reservoir and the supply pipes to supply the heated water to the supply pipes.

5 According to the present invention, desirably, the apparatus further includes a curing blanket covered on the outer surface of the mass concrete to absorb a portion of the heated cooling water or the heated water being discharged through the holes, thereby allowing the absorbed heated
10 cooling water or the absorbed heated water to be contacted with the outer surface of the mass concrete.

 According to the present invention, desirably, the apparatus further includes a heat-retaining member covered on the curing blanket to keep the heat of the heated cooling
15 water or the heated water absorbed to the curing blanket.

 According to the present invention, desirably, the heat-retaining member is formed of vinyl canvas or bubble sheets.

 According to the present invention, desirably, the auxiliary water reservoir includes heating means adapted to
20 heat the heated water stored thereinto.

 According to the present invention, desirably, the apparatus further includes a surface portion temperature sensor disposed on the outer surface of the mass concrete to measure the temperature of the outer surface of the mass
25 concrete and a center portion temperature sensor disposed in the interior of the mass concrete to measure the temperature of the interior of the mass concrete, wherein the control unit is connected to the heating means to supply power to the heating means and operates the switching valves if the
30 temperature of the interior of the mass concrete obtained from the center portion temperature sensor is less than the set temperature, so that the supply of the heated cooling

water from the pipes to the hoses stops and the heated water from the supply pipes to the hoses is supplied.

According to the present invention, desirably, the apparatus further includes a connection pipe provided between
5 the auxiliary water reservoir and the main water reservoir to supply the cooling water stored in the main water reservoir to the auxiliary water reservoir.

According to the present invention, desirably, the control unit controls the first pumps to adjust the flow rate
10 of the cooling water being supplied to the pipes and the second pumps to adjust the flow rate of the heated water being supplied to the hoses.

According to the present invention, desirably, the temperature difference from the interior to the outer surface
15 of the mass concrete is calculated by the control unit, and if the temperature difference calculated by the control unit is more than the set temperature difference, the first pumps are operated to supply the cooling water to the pipes.

To accomplish the above objects, according to a second
20 aspect of the present invention, there is provided a method for reducing a temperature difference generated in mass concrete, the method including the steps of: assembling iron bars, setting up a form, and disposing at least one or more pipes inside the form in such a manner as to be passed
25 through the mass concrete built by casting concrete in the form; disposing at least one or more hoses, each having a plurality of holes formed on the outer periphery thereof, on the outer surface of the mass concrete, connecting the other side ends of the pipes to the hoses and one side ends of the
30 pipes to a main water reservoir into which the cooling water is stored; and disposing an auxiliary water reservoir in which heated water is stored and supply pipes adapted to

supply the heated water to the outer surface of the mass concrete; disposing water recovery ducts on the sides of the mass concrete or forming water passages on the edges where the mass concrete and the ground meets each other; supplying
5 the cooling water stored in the main water reservoir to the pipes by means of first pumps, when the temperature difference from the interior to the outer surface of the mass concrete is generated; cooling the interior of the mass concrete by the cooling water supplied to the pipes and
10 supplying the heated cooling water to the hoses; discharging the heated cooling water through the holes of the hoses to heat the outer surface of the mass concrete, collecting the heated cooling water to the water passages or the water recovery ducts, returning the heated cooling water to the
15 main water reservoir through water recovery pipes connected to the water passages or the water recovery ducts and water recovery pumps mounted on the water recovery pipes; and if the temperature of the interior of the mass concrete is less than a set temperature, stopping the operations of the first
20 pumps by a control unit to shut off the supply of the cooling water supplied to the pipes, operating second pumps disposed between the supply pipes and the auxiliary water reservoir by the control unit to supply the heated water to the outer surface of the mass concrete through the supply pipes.

25 According to the present invention, desirably, the step of disposing the supply pipes further includes the step of disposing switching valves between the pipes and the hoses in such a manner as to be connected to the supply pipes, and the step of supplying the heated water to the outer surface of
30 the mass concrete further comprises the steps of operating the switching valves by the control unit to shut off the supply of the cooling water supplied to the pipes and

supplying the heated water to the hoses through the supply pipes if the temperature of the interior of the mass concrete is less than the set temperature.

According to the present invention, desirably, the step
5 of disposing the supply pipes further includes the step of disposing a curing blanket on the outer surface of the mass concrete, so that the curing blanket absorbs a portion of the heated water discharged through the plurality of holes of the hoses thereto, in the step of collecting the heated cooling
10 water.

According to the present invention, desirably, after the step of disposing the curing blanket, a heat-retaining member is covered on the curing blanket.

According to the present invention, desirably, the
15 method further includes the step of supplying power to heating means mounted inside the auxiliary water reservoir by the control of the control to heat the heated water.

According to the present invention, desirably, the flow rate of the cooling water being supplied to the pipes and the
20 flow rate of the heated water being supplied to the supply pipes are adjusted by the control unit.

According to the present invention, desirably, the temperature difference from the interior to the outer surface of the mass concrete is calculated by the control unit, based
25 upon the temperatures of the outer surface and the interior of the mass concrete obtained from a surface portion temperature sensor disposed on the outer surface of the mass concrete and a center portion temperature sensor disposed in the interior of the mass concrete, so that if the temperature
30 difference calculated by the control unit is more than the set temperature difference, the first pumps are operated.

According to the present invention, desirably, before the step of supplying the heated water to the outer surface of the mass concrete, a connection pipe is disposed between the main water reservoir and the auxiliary water reservoir to
5 supply the cooling water stored in the main water reservoir to the auxiliary water reservoir.

According to the present invention, desirably, after the curing process of the mass concrete is completed, the pipes are filled by means of grouting.

10 According to the present invention, desirably, the mass concrete is cured by the method for reducing a temperature difference.

【Advantageous Effects】

According to the present invention, the hoses each
15 having the plurality of holes formed on the outer periphery thereof are disposed on the outer surface of the mass concrete, thereby increasing the temperature of the outer surface of the mass concrete, and at the same time, the pipes are disposed in the interior of the mass concrete, along
20 which the cooling water flows, thereby cooling the interior of the mass concrete, so that the temperature difference from the interior to the outer surface of the mass concrete is reduced to prevent the internal cracks caused by high temperature difference.

25 In the intermediate step of the curing process, moreover, if the temperature of the interior of the mass concrete is less than the set temperature (for example, about 50°C), the supplied cooling water is not heated anymore to make the outer surface of the mass concrete not heated efficiently, so
30 that the switching valves are operated to supply the heated water to the outer surface, thereby efficiently reducing the temperature difference.

Also, the temperature of the outer surface of the mass concrete is increased to reduce the temperature difference from the interior to the outer surface of the mass concrete and thus to prevent the internal cracks caused by high temperature difference, and further, the curing blanket, which absorbs the heated cooling water or the heated water thereto, is always contacted with the outer surface of the mass concrete, thereby effectively heating the outer surface of the mass concrete and preventing the surface cracks caused by the dry shrinkage of the mass concrete.

Additionally, the heat-retaining member is covered on the curing blanket, thereby maintaining the temperature of the heated water for long hours and increasing the heating efficiency of the outer surface of the mass concrete. Also, the hoses having the plurality of holes are disposed on the upper end portions of the mass concrete, and thus, the heated water naturally flowing along the outer surface of the mass concrete gathers to the water recovery ducts and is returned to the main water reservoir through the water recovery pipes, so that the water is circulated with relatively small power, which gives economical advantages.

【Description of Drawings】

FIG.1a is a graph showing the outer surface temperature of mass concrete, the internal temperature thereof and the difference between the two temperatures during curing of poured concrete.

FIG.1b is a schematic view showing a conventional apparatus for reducing cracks caused by dry shrinkage by injecting water into the outer surface of mass concrete through pipes.

FIG.1c is a schematic view showing another conventional apparatus for reducing a temperature difference in mass

concrete, wherein pipes are disposed inside the mass concrete, through which cooling water flows.

FIG.2 is a perspective view showing an apparatus for reducing a temperature difference in mass concrete according to a first embodiment of the present invention.

FIG.3a is a sectional view taken along the line A-A' of FIG.2.

FIG.3b is a plan view showing the apparatus according to the first embodiment of the present invention.

FIG.4 is a block diagram showing the signal flows of the apparatus according to the first embodiment of the present invention.

FIG.5 is a flow chart showing a method for reducing a temperature difference in mass concrete according to the first embodiment of the present invention.

FIG.6 is a graph showing the outer surface temperature of mass concrete, the internal temperature thereof and the difference between the two temperatures during curing of poured concrete in accordance with the curing time through the method according to the first embodiment of the present invention.

FIG.7 is a perspective view showing an apparatus for reducing a temperature difference in mass concrete according to a second embodiment of the present invention.

FIG.8 is a plan view showing the apparatus according to the second embodiment of the present invention.

FIG.9 is a block diagram showing the signal flows of the apparatus according to the second embodiment of the present invention.

FIG.10 is a flow chart showing a method for reducing a temperature difference in mass concrete according to the second embodiment of the present invention.

【Best Mode for Invention】

Hereinafter, an explanation on an apparatus and method for reducing a temperature difference in mass concrete during curing according to the present invention will be given with
5 reference to the attached drawings. In the detailed description on the operating principle of the preferred embodiment of the present invention, an explanation on their functions or configurations well known in the art will be avoided for the brevity of the description.

10 Further, in the description of the invention with reference to the attached drawings, further, the same components are indicated by the same reference numerals as each other. On the other hand, if it is expressed that a component is "connected" or "coupled" to another component,
15 it should be understood that the component is connected or coupled to another component, and alternatively, another component is interposed between the connected or coupled two components. Therefore, the terms used in the description does not define the present invention, but are defined as the
20 concepts conforming to the technical spirit of the invention on the basis where the terms are appropriately defined to explain the invention best.

[Configuration of an apparatus for reducing a temperature difference in mass concrete according to a first embodiment
25 of the present invention and a method for reducing a temperature difference in mass concrete using the apparatus]

Hereinafter, an explanation on a configuration of an apparatus for reducing a temperature difference in mass concrete according to a first embodiment of the present
30 invention will be given. First, FIG.2 is a perspective view showing an apparatus for reducing a temperature difference in mass concrete according to a first embodiment of the present

invention. As shown in FIG.2, an apparatus for reducing a temperature difference in the mass concrete largely includes hoses 300 disposed on the upper portion of the outer surface 20 of the mass concrete 10, pipes 120 disposed passed through the interior 50 of the mass concrete 10, a main water reservoir 100 in which cooling water 60 is stored, first pumps 110, water recovery ducts 400, a curing blanket 200, a heat-retaining member 210, water recovery pipes 130, an auxiliary water reservoir 700 in which heated water 61 is stored, second pumps 730, supply pipes 710 adapted to supply the heated water 61 therethrough, a connection pipe 740 adapted to connect the main water reservoir 100 and the auxiliary main reservoir 700, a third pump 750, and a control unit 600.

As shown in FIG.2, the pipes 120 are passed buriedly through the interior 50 of the mass concrete 10. The pipes 120 are disposed inside a form before concrete casting and are buried in the interior 50 of the mass concrete 10. The pipes 120 are connected to the main water reservoir 100 into which the cooling water 60 is stored. Water is supplied to the main water reservoir 100, and a given amount of cooling water 60 is stored therein. Further, the first pump 110 is mounted between each pipe 120 and the main water reservoir 100 to supply the cooling water 60 stored in the main water reservoir 100 to each pipe 120.

The cooling water 60 stored in the main water reservoir 100 is supplied to the pipes 120 by means of the first pumps 110. The cooling water 60 supplied to the pipes 120 is heated by the internal temperature of the mass concrete 10. That is, in the initial step of the curing process, the internal temperature of the mass concrete 10 becomes within a range between about 60°C and 100°C, and the temperature of

the cooling water becomes within a range between about 0°C and 30°C. Through the heat transmission therebetween, accordingly, the cooling water 60 is heated and the interior 50 of the mass concrete 10 is cooled.

5 The cooling water 60 is heated by means of the temperature of the interior 50 of the mass concrete 10 and is supplied to the hoses 300 in a state of being heated. The cooling water 60 stored in the main water reservoir 100 is supplied to the pipes 120 by means of the first pumps 110, and the first pumps 110 are controlled by the control unit 600, thereby adjusting the supply speed of the cooling water 60 and the flow rate in the pipes 120. That is, the first pumps 110 are composed of inverter pumps controllable by means of the control signal applied from the control unit 600. Accordingly, the cooling water 60 is supplied to the pipes 120 at a given flow rate capable of enhancing the heat exchange efficiency between the cooling water 60 existing inside the pipes 120 and the interior 50 of the mass concrete 10. Further, the flow rate of the cooling water 60 in the pipes 120 determines the temperature of the heated cooling water supplied to the hoses 300. Under the control of the control unit 600, the flow rate of the cooling water 60 in the pipes 120 is adjusted to allow the temperature of the heated cooling water being supplied to the hoses 300 to be within a range between 40°C and 70°C.

 The hoses 300 are connected correspondingly to the pipes 120 in such a manner as to be disposed on the outer surface 20 of the mass concrete 10. As shown in FIG.2, each hose 300 is closed at the end thereof and has a plurality of holes 310 formed on the outer periphery thereof. Therefore, the heated cooling water supplied to the hoses 300 is discharged through the plurality of holes 310 of the hoses 300. As shown in

FIG.2, the hoses 300 are located on relatively high positions on the outer surface 20 of the mass concrete 10, so that the heated cooling water being discharged through the holes 310 naturally flows downwardly along the outer surface 20 of the mass concrete 10 by its gravity.

According to the first embodiment of the present invention, further, the apparatus includes the water recovery ducts 400. As shown in FIG.2, the water recovery ducts 400 are formed along both sides of the lower end of the mass concrete 10. Instead of the water recovery ducts 400, water passages may be formed between the mass concrete 10 and the ground to collect the heated cooling water. Accordingly, the heated cooling water gathers in the water recovery ducts 400 and is then collected to the main water reservoir 400 through respective water recovery pipes 130.

The outer surface 20 of the mass concrete 10 is heated by the heated cooling water discharged through the holes 310 of the hoses 300. That is, the temperature of the heated cooling water becomes in a range between 40°C and 70°C, and the temperature of the outer surface 20 of the mass concrete 10 becomes in a range between 10°C and 30°C, so that the outer surface 20 can be heated by the heated cooling water. Therefore, the interior 50 of the mass concrete 10 is cooled, and at the same time, the outer surface 20 of the mass concrete 10 is heated, thereby reducing a temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10.

During the curing process, further, if the temperature of the interior 50 of the mass concrete 10 is less than a set temperature (for example, about 50°C), the supplied cooling water is not heated anymore to stop the heating of the outer surface 20. Therefore, if the temperature of the interior of

the mass concrete 10 is less than the set temperature, the operations of the first pumps 110 stop by the control of the control unit 600 to shut off the supply of the cooling water 60 to the pipes 120. Further, the second pumps 730 are
 5 operated by means of the control unit 600 to supply the heated water 61 stored in the auxiliary water reservoir 700 to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

As shown in FIG.2, the auxiliary water reservoir 700 has
 10 heating means 500 mounted therein and keeps the stored heated water 61 to a temperature in a range between 40°C and 70°C. Therefore, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710, thereby heating the
 15 outer surface 20 of the mass concrete 10. Further, the connection pipe 740 is provided between the auxiliary water reservoir 700 and the main water reservoir 100. Thus, the cooling water 60 stored in the main water reservoir 100 is supplied to the auxiliary water reservoir 700, and the
 20 cooling water 60 is heated by means of the heating means 500 mounted inside the auxiliary water reservoir 700 and supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

FIG.3a is a sectional view taken along the line A-A' of
 25 FIG.2. As shown in FIG.3a, the pipes 120 are disposed passed through the interior 50 of the mass concrete 10. Thus, the cooling water 60 flows along the interiors of the pipes 120, thereby cooling the interior 50 of the mass concrete 10. As shown in FIG.3a, the hoses 300 are located at the upper end
 30 portion on the highest position of the outer surface 20 of the mass concrete 10. Accordingly, the heated cooling water 60 being discharged through the holes 310 naturally flows

downwardly along the outer surface 20 of the mass concrete 10 and then gathers to the water recovery ducts 400. Further, the curing blanket 200 is covered on the outer surface 20 of the mass concrete 10. The water recovery pipe 130 is
5 disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and a water recovery pump (not shown) is further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

10 The curing blanket 200 is made of a cotton material like a non-woven fabric. Accordingly, a portion of the heated cooling water being discharged through the holes 310 is absorbed to the curing blanket 200. Thus, the curing blanket 200 to which the heated cooling water is absorbed is always
15 brought into close contact with the outer surface 20 of the mass concrete 10, so that the heated cooling water is always contacted with the outer surface 20 of the mass concrete 10. The temperature of the heated cooling water being discharged through the holes 310 of the hoses 300 is in a range between
20 40°C and 70°C, and the temperature of the outer surface 20 of the mass concrete 10 is in a range between about 10°C and 30°C, so that the outer surface 20 is heated by the heated cooling water 40 discharged through the holes 310.

Moreover, a surface portion temperature sensor 71 and a
25 center portion temperature sensor 72 are disposed correspondingly on the outer surface 20 of the mass concrete 10 and the interior 50 thereof. The center portion temperature sensor 72 disposed in the interior 50 of the mass concrete 10 is mounted inside the form before concrete
30 casting.

As the surface portion temperature sensor 71 disposed on the outer surface 20 of the mass concrete 10 and the center

portion temperature sensor 72 disposed on the interior 50 thereof are under the control of the control unit 600, accordingly, a temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10 can be calculated. Based on the calculated temperature difference, the first pumps 110 are controlled to adjust the flow rate of the cooling water 60, thereby controlling the temperature of the heated cooling water.

The curing blanket 200 is provided to increase the heating efficiency. The curing blanket 200 is always brought into close contact with the outer surface 20 of the mass concrete 10, so that the heated cooling water being discharged through the holes 310 of the hoses 300 is always contacted with the outer surface 20 of the mass concrete 10 and thus heats the outer surface 20 of the mass concrete 10 more rapidly. Also, the curing blanket 200 and the hoses 300 are covered by the heat-retaining member 210. The heat-retaining member 210 is covered on the curing blanket 200, thereby keeping the heat of the heated water 61. That is, the temperature of the heated water 61 is maintained for long hours, thereby increasing the heating efficiency. The heat-retaining member 210 is formed of vinyl canvas, bubble sheets and the like, which has heat-retaining effects.

During the curing process, further, if the temperature of the interior of the mass concrete 10 is less than the set temperature (for example, about 50°C), the supplied cooling water 60 is not heated anymore to stop the heating of the outer surface 20. Therefore, if the temperature of the interior of the mass concrete 10 is less than the set temperature, the operations of the first pumps 110 stop by the control of the control unit 600 to shut off the supply of the cooling water 60 to the pipes 120. Further, the second

pumps 730 are operated by means of the control unit 600 to supply the heated water 61 stored in the auxiliary water reservoir 700 to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

5 The auxiliary water reservoir 700 has the heating means 500 mounted therein and keeps the stored heated water 61 to a temperature in a range between 40°C and 70°C. Therefore, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10
10 through the supply pipes 710, thereby heating the outer surface 20 of the mass concrete 10.

FIG.3b is a plan view showing the apparatus according to the first embodiment of the present invention. As shown in FIG.3b, the cooling water 60 stored in the main water
15 reservoir 100 is supplied to the pipes 120 disposed in the interior 50 of the mass concrete 10. The first pumps 110 are controlled by the control unit 600 to adjust the flow rate of the cooling water 60 being supplied to the pipes 120. In the initial step of the curing process, further, the cooling
20 water 60 flowing along the interiors of the pipes 120 is heated, and the interior 50 of the mass concrete 10 is cooled.

The cooling water 60 heated in the pipes 120 is supplied as the heated cooling water to the hoses 300, and the heated cooling water supplied to the hoses 300 is discharged through
25 the holes 310 of the hoses 300. As shown in FIG.3b, next, the heated cooling water being discharged through the holes 300 naturally flows along the outer surface 20 and gathers to the water recovery ducts 400.

As mentioned before, since the curing blanket 200 is
30 covered on the outer surface 20, the outer surface 20 of the mass concrete 10 is heated by the heated cooling water absorbed to the curing blanket 200. Further, since the heat-

retaining member 210 is covered on the curing blanket 200, the temperature of the heated cooling water can be maintained for longer hours. As shown in FIG.3b, the heated cooling water gathering to the water recovery ducts 400 is returned to the main water reservoir 100 through the water recovery pipes 130. The water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

During the curing process, further, if the temperature of the interior of the mass concrete 10 is less than the set temperature, the supplied cooling water 60 is not heated anymore to stop the heating of the outer surface 20.

Therefore, if the temperature of the interior of the mass concrete 10 is less than the set temperature, the operations of the first pumps 110 stop by the control of the control unit 600 to shut off the supply of the cooling water 60 to the pipes 120. Further, the second pumps 730 are operated by means of the control unit 600 to supply the heated water 61 stored in the auxiliary water reservoir 700 to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

As shown in FIG.3b, the auxiliary water reservoir 700 has the heating means 500 mounted therein and keeps the stored heated water 61 to a temperature in a range between 40°C and 70°C. Therefore, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710, thereby heating the outer surface 20 of the mass concrete 10. The heating water 61 supplied to the outer surface 20 is absorbed to the curing blanket 200, and the

rest thereof gathers to the water recovery ducts 400. Next, the heating water 61 is collected to the main water reservoir 100 through the water recovery pipes 130 connected to the water recovery ducts 400. So as to collect the heated water 5 61 to the main water reservoir 100, the water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 10 through the water recovery pipe 130. The connection pipe 740 is provided between the auxiliary water reservoir 700 and the main water reservoir 100. Thus, the cooling water 60 stored in the main water reservoir 100 is supplied to the auxiliary water reservoir 700, and the heated water 61 heated by means 15 of the heating means 500 mounted inside the auxiliary water reservoir 700 is supplied circulatedly to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

FIG.4 is a block diagram showing the signal flows of the apparatus according to the first embodiment of the present 20 invention. The center portion temperature sensor 72 is disposed in the interior 50 of the mass concrete 10, and the surface portion temperature sensor 71 is disposed on the outer surface 20 of the mass concrete 10. Accordingly, the temperature of the interior 50 of the mass concrete 10 is 25 transmitted from the center portion temperature sensor 72 to the control unit 600, and the temperature of the outer surface 20 of the mass concrete 10 is transmitted from the surface portion temperature sensor 71 to the control unit 600. Thus, the temperature difference from the interior 50 to the 30 outer surface 20 of the mass concrete 10 is calculated in real time by mean of the control unit 600.

The curing process for the mass concrete 10 starts, and if the temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10 is more than the set temperature by the occurrence of hydration heat, the first
5 pumps 110 are operated by the control unit 600 to supply the cooling water 60 to the pipes 120.

Further, temperature sensors may be mounted inside the pipes 120, the supply pipes 710 and the hoses 300. Thus, the internal temperatures of the pipes 120 and the supply pipes
10 710 and the temperature of the heated cooling water flowing along the hoses 300 are sensed by means of the temperature sensors. The first pumps 110 are controlled by means of the control unit 600 in such a manner as to be adjusted in the flow rate of the cooling water 60 being supplied to the pipes
15 120, based upon the temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10, the internal temperatures of the pipes 120 and the temperature of the heated water 61. The flow rate of the cooling water 60 flowing along the pipes 120 determines the temperature of the
20 heated cooling water.

Moreover, power is supplied to the heating means 500 mounted inside the auxiliary water reservoir 700 under the control of the control unit 600. Based upon the internal temperature of the mass concrete 10, thus, the heated water
25 61 is heated to the temperature in a range between 40°C and 80°C and the flow rate of the heated water 61 being supplied through the supply pipes 710 is controlled.

If the temperature of the interior of the mass concrete 10 is more than the set temperature, the second pumps 730 are
30 not operated under the control unit 600, but if it is less than the set temperature, the operations of the first pumps 110 stop and the second pumps 730 are operated by the control

of the control unit 600, so that the supply of the cooling water 60 to the pipes 120 stops, and the second pumps 730 are operated to supply the heated water 61 to the outer surface 20 of the mass concrete 10 through the supply pipes 710.

5 Hereinafter, an explanation on a method for reducing a temperature difference in mass concrete during curing according to the first embodiment of the present invention will be given. First, FIG.5 is a flow chart showing a method for reducing a temperature difference in mass concrete
10 according to the first embodiment of the present invention. So as to build the mass concrete 10, iron bars are assembled, and a form is set up. Next, the pipes 120 are disposed inside the form, and further, the temperature sensors 71 and 72 are disposed inside the form. After that, concrete is
15 cast into the form to build the mass concrete 10 (at step S10-1).

Each pipe 120 is connected at one side end thereof to the main water reservoir 100 into which the cooling water 60 is stored and connected at the other side end thereof to the
20 corresponding hose 300. The hoses 300 connected to the pipes 120 are disposed on the outer surface 20 of the mass concrete 10 (at step S20-1). As mentioned above, the hoses 300 are closed on one ends thereof and have the plurality of holes 310 formed on the outer periphery thereof. The hoses 300 are
25 disposed on the outer surface 20 of the mass concrete 10.

As the curing process for the mass concrete 10 starts, the temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10 is generated by the occurrence of hydration heat (at step S30-1). The
30 temperatures of the outer surface 20 and the interior 50 are sensed by means of the temperature sensors 71 and 72 mounted at the outer surface 20 and the interior 50 of the mass

concrete 10. Thus, the temperature difference between the outer surface 20 and the interior 50 is calculated in real time by means of the control unit 600.

Based upon the calculated temperature difference, the supply speed, that is, the flow rate of the cooling water 60 being supplied to the pipes 120 is determined by means of the control unit 600. As described above, the flow rate of the cooling water 60 flowing along the pipes 120 determines the temperature of the heated cooling water being supplied to the hoses 300. Accordingly, based upon the temperature difference calculated in real time, the flow rate of the cooling water 60 being supplied to the pipes 120 can be adjusted in real time by means of the control unit 600.

The first pumps 110 are controlled by the control unit 600 to supply the cooling water 60 to the pipes 120 at a set flow rate (at step S40-1). The cooling water 60 being supplied to the pipes 120 flows and is heated therein. In the initial curing step, that is, the temperature of the cooling water 60 becomes within a range between about 0°C and 30°C, and the temperature of the interior 50 of the mass concrete 10 becomes within a range between about 70°C and 100°C, so that the interior 50 of the mass concrete 10 is cooled by the cooling water 60 (at step S50-1). At the same time, the cooling water 60 being supplied to the pipes 120 is heated. The heated cooling water 60 is supplied to the hoses 300 (at step S60-1). As mentioned above, the temperature of the heated cooling water 60 being supplied to the hoses 300 is determined by the temperature of the interior 50 of the mass concrete 10 and the flow rate of the cooling water 60 flowing along the pipes 120. The flow rate of the cooling water 60 is adjusted by means of the control unit 600 to

maintain the temperature of the heated cooling water 60 to be in a range between 40°C and 70°C.

5 The heated cooling water supplied to the hoses 300 is discharged through the plurality of holes 310 formed on the outer periphery of the hoses 300 (at step S70-1). As mentioned above, the hoses 300 are located on the outer surface 20 of the mass concrete 10, so that the heated cooling water being discharged through the holes 310 naturally flows downwardly along the outer surface 20 of the mass concrete 10. Further, the curing blanket 200 is covered on the outer surface 20 of the mass concrete 10. Accordingly, a portion of the heated cooling water being discharged through the holes 310 is absorbed to the curing blanket 200, thereby heating the outer surface 20 of the mass concrete 10 (at step S80-1). Also, the heat-retaining member 210 is covered on the curing blanket 200 to provide heat retaining efficiencies, thereby efficiently heating the outer surface 20. Therefore, the interior 50 of the mass concrete 10 is cooled by means of the cooling water 60 flowing along the pipes 120, and the outer surface 20 of the mass concrete 10 is heated by means of the heated cooling water being discharged through the holes 310 of the hoses 300, thereby reducing a temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10.

25 The heated cooling water being discharged through the holes 310 of the hoses 300 gathers to the water recovery ducts 400 and is returned to the main water reservoir 100 through the water recovery pipes 130 (at step S90-1). The circulation is kept until the temperature of the interior 50 of the mass concrete 10 is less than the set temperature. So as to allow the heated cooling water to be returned to the main water reservoir 100, the water recovery pipe 130 is

disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

Further, if the temperature of the interior 50 of the mass concrete 10 is less than a set temperature (for example, about 50°C), it is too low to heat the supplied cooling water anymore, thereby stopping heating the outer surface 20.

Therefore, if the temperature of the interior of the mass concrete 10 is less than the set temperature (at step S100-1), the operations of the first pumps 110 stop by the control of the control unit 600 to shut off the supply of the cooling water 60 to the pipes 120 (at step S110-1). Further, the second pumps 730 are operated by means of the control unit 600 to supply the heated water 61 stored in the auxiliary water reservoir 700 through the supply pipes 710 (at step S120-1).

The heated water 61 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710 (at step S130-1). Accordingly, the outer surface 20 of the mass concrete 10 is heated by the heated water 61 (at step S140-1).

Also, the auxiliary water reservoir 700 has the heating means 500 mounted therein and keeps the stored heated water 61 to a temperature in a range between 40°C and 70°C. Therefore, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710, thereby heating the outer surface 20 of the mass concrete 10. The heating water 61 supplied to the outer surface 20 is absorbed to the curing blanket 200, and the rest thereof gathers to the water recovery ducts 400. Next, the heating water 61 is collected

to the main water reservoir 100 through the water recovery pipes 130 connected to the water recovery ducts 400. So as to collect the heated water 61 to the main water reservoir 100, the water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

The connection pipe 740 is provided between the auxiliary water reservoir 700 and the main water reservoir 100. Thus, the cooling water 60 stored in the main water reservoir 100 is supplied to the auxiliary water reservoir 700, and the heated water 61 heated by means of the heating means 500 mounted inside the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710. The circulation starts at the time when the temperature of the interior 50 of the mass concrete 10 is less than the set temperature and is kept until the curing process is completed (at step 150-1). After the curing process for the mass concrete 10 is completed, finally, the pipes 120 are filled by means of grouting to finish the formation of the mass concrete 10.

FIG.6 is a graph showing the outer surface temperature of mass concrete, the internal temperature thereof and the difference between the two temperatures during curing of poured concrete in accordance with the curing time through the method according to the first embodiment of the present invention. As shown in FIG.6, the time until the curing is completed needs about 4 to 7 days. When compared with the graph in FIG.1c, it is appreciated that the curing time is more reduced in FIG.6. When the method according to the first embodiment of the present invention is carried out, further,

the degree of increase of the temperature of the interior 50 of the mass concrete 10 is decreased, and the temperature of the outer surface 20 of the mass concrete 10 is increased. Accordingly, the temperature difference from the interior 50 to the outer surface 20 of the mass concrete is reduced. As shown in FIG.6, also, the maximum temperature difference $\Delta T = T_1 - T_2$ is more decreased when compared with that in FIG.1c.

[Configuration of an apparatus for reducing a temperature difference in mass concrete according to a second embodiment of the present invention and a method for reducing a temperature difference in mass concrete using the apparatus]

Hereinafter, an explanation on a configuration of an apparatus for reducing a temperature difference in mass concrete according to a second embodiment of the present invention will be given. FIG.7 is a perspective view showing an apparatus for reducing a temperature difference in mass concrete according to a second embodiment of the present invention, and FIG.8 is a plan view showing the apparatus according to the second embodiment of the present invention.

In the same manner as in the first embodiment of the present invention, as shown in FIGS.7 and 8, the apparatus for reducing a temperature difference in mass concrete according to the second embodiment of the present invention includes hoses 300 disposed on the upper portion of the outer surface 20 of the mass concrete 10, pipes 120 disposed passed through the interior 50 of the mass concrete 10, a main water reservoir 100 in which cooling water 60 is stored, first pumps 110, water recovery ducts 400, a curing blanket 200, a heat-retaining member 210, water recovery pipes 130, an auxiliary water reservoir 700 in which heated water 61 is stored, second pumps 730, supply pipes 710 adapted to supply

the heated water 61 therethrough, a connection pipe 740 adapted to connect the main water reservoir 100 and the auxiliary main reservoir 700, a third pump 750, and a control unit 600.

5 Unlike the apparatus according to the first embodiment of the present invention, however, the apparatus according to the second embodiment of the present invention further includes a switching valve 720 mounted at a position where each supply pipe 710 meets a coupled portion between each
10 pipe 120 and each hose 300. Hereinafter, the apparatus for reducing a temperature difference in mass concrete according to the second embodiment of the present invention will be explained with respect to the differences from the apparatus according to the first embodiment of the present invention.

15 In the initial step of the curing process (if the temperature of the interior 50 of the mass concrete 10 is more than a set temperature), the switching valves 720 are controlled by the control unit 600 to shut off the supply of the heated water 61 to the hoses 300 through the supply pipes
20 710, and the cooling water 60 is supplied from the main water reservoir 100 to the pipes 120. In the initial step of the curing process, accordingly, the first pumps 110 are operated by the control of the control unit 600 to move the cooling water 60 to the pipes 120 from the main water reservoir 100,
25 and by means of the cooling water 60 being supplied to the pipes 120, the interior 50 of the mass concrete 10 is cooled. At the same time, the cooling water 60 is heated and supplied as the heated cooling water to the hoses 300. In the same manner as in the first embodiment of the present invention,
30 the heated cooling water being supplied to the hoses 300 is discharged through the holes 310 to heat the outer surface 20 of the mass concrete 10 and gathers to the water recovery

ducts 400. Next, the heated cooling water is returned to the main water reservoir 100 through the water recovery pipes 130. The water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and a water recovery pump (not shown) is further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

In the intermediate step of the curing process (if the temperature of the interior 50 of the mass concrete 10 is less than the set temperature), the switching valves 720 are controlled by the control unit 600 to shut off the supply of the cooling water 60 to the hoses 300, and the heated water 61 is supplied to the hoses 300 through the supply pipes 710. That is, if the temperature of the interior 50 of the mass concrete 10 is less than the set temperature, the cooling water 60 supplied to the pipes 120 is not heated anymore, so that the switching valves 720 are operated to stop the circulation between the pipes 120 and the hoses 400.

If the supply pipes 710 and the hoses 300 are open by the operations of the switching valves 720, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the hoses 300 through the supply pipes 710. Accordingly, the heated water 61 being supplied to the hoses 300 is discharged through the holes 310 to heat the outer surface 20 of the mass concrete 10 and gathers to the water recovery ducts 400. Next, the heated water is returned to the main water reservoir 100 through the water recovery pipes 130. The water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130. The

main water reservoir 100 and the auxiliary water reservoir 700 are connected to each other by means of the connection pipe 740. The auxiliary water reservoir 700 has heating means 500 mounted therein, and the heating means 500 heats the heated water 61 stored in the auxiliary water reservoir 700.

FIG.9 is a block diagram showing the signal flows of the apparatus according to the second embodiment of the present invention. As shown in FIG.9, the temperature of the interior 50 of the mass concrete 10 sensed by the center portion temperature sensor disposed in the interior of the mass concrete 10 is transmitted to the control unit 600, and the temperature of the outer surface 20 of the mass concrete 10 sensed by the surface portion temperature sensor disposed on the outer surface of the mass concrete 10 is transmitted to the control unit 600, so that the temperature difference is in real time calculated.

If the curing process starts, the first pumps 110 are operated by the control unit 600 to supply the cooling water 60 stored in the main water reservoir 100 to the pipes 120. If the temperature of the interior 50 of the mass concrete 10 is less than the set temperature, the switching valves 720 are operated by the control unit 600 to shut off the connected portions between the pipes 120 and the hoses 300. Then, the connected portions between the supply pipes 710 and the hoses 300 are open. Accordingly, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the hoses 300 through the supply pipes 710. The heating means 500 is controlled by the control unit 600 to make the heated water 61 stored in the auxiliary water reservoir 700 have a temperature in a range between 40°C and 80°C.

Hereinafter, an explanation on a method for reducing a temperature difference in mass concrete during curing according to the second embodiment of the present invention will be given. First, FIG.10 is a flow chart showing a method
5 for reducing a temperature difference in mass concrete according to the second embodiment of the present invention. First of all, iron bars are assembled, and a form is set up. Next, the pipes 120 are disposed inside the form, and further, the temperature sensors 71 and 72 are disposed inside the
10 form. After that, concrete is cast into the form to build the mass concrete 10 (at step S10-2).

Each pipe 120 is connected at one side end thereof to the main water reservoir 100 into which the cooling water 60 is stored and connected at the other side end thereof to the
15 corresponding hose 300. The hoses 300 connected to the pipes 120 are disposed on the outer surface 20 of the mass concrete 10 (at step S20-2). As mentioned above, the hoses 300 are closed on one ends thereof and have the plurality of holes 310 formed on the outer periphery thereof.

As the curing process for the mass concrete 10 starts, the temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10 is generated by the occurrence of hydration heat (at step S30-2). The temperatures of the outer surface 20 and the interior 50 are
25 sensed by means of the temperature sensors 71 and 72 mounted at the outer surface 20 and the interior 50 of the mass concrete 10. Thus, the temperature difference between the temperature of the outer surface 20 and the temperature of the interior 50 is calculated in real time by means of the
30 control unit 600.

Based upon the calculated temperature difference, the supply speed, that is, the flow rate of the cooling water 60

being supplied to the pipes 120 is determined by means of the control unit 600. As described above, the flow rate of the cooling water 60 flowing along the pipes 120 determines the temperature of the heated cooling water supplied to the hoses 300. Accordingly, based upon the temperature difference calculated in real time, the flow rate of the cooling water 60 being supplied to the pipes 120 can be adjusted in real time by means of the control unit 600.

In the initial step of the curing process, the switching valves 720 are operated by the control unit 600 to shut off the connected portions between the supply pipes 710 and the hoses 300. Then, the connected portions between the pipes 120 and the hoses 300 are open. The first pumps 110 are controlled by the control unit 600 to supply the cooling water 60 to the pipes 120 at a set flow rate (at step S40-2). The cooling water 60 being supplied to the pipes 120 flows and is heated thereinto. In the initial curing step, that is, the temperature of the cooling water 60 supplied to the pipes 120 becomes within a range between about 0°C and 30°C, and the temperature of the interior 50 of the mass concrete 10 becomes within a range between about 70°C and 100°C, so that the interior 50 of the mass concrete 10 is cooled by the cooling water 60 (at step S50-2). At the same time, the cooling water 60 supplied to the pipes 120 is heated. The heated cooling water 60 is supplied to the hoses 300 (at step S60-2). As mentioned above, the temperature of the heated cooling water 60 being supplied to the hoses 300 is determined by the temperature of the interior 50 of the mass concrete 10 and the flow rate of the cooling water 60 flowing along the pipes 120. The flow rate of the cooling water 60 is adjusted by means of the control unit 600 to maintain the

temperature of the heated cooling water 60 to be in a range between 40°C and 70°C.

The heated cooling water being supplied to the hoses 300 is discharged through the plurality of holes 310 formed on the outer periphery of the hoses 300 (at step S70-2). As mentioned above, the hoses 300 are located on the outer surface 20 of the mass concrete 10, so that the heated cooling water discharged through the holes 310 naturally flows downwardly along the outer surface 20 of the mass concrete 10. Further, the curing blanket 200 is covered on the outer surface 20 of the mass concrete 10. Accordingly, a portion of the heated cooling water being discharged through the holes 310 is absorbed to the curing blanket 200, thereby heating the outer surface 20 of the mass concrete 10 (at step S80-2).

Also, the heat-retaining member 210 is covered on the curing blanket 200 to provide heat retaining efficiencies, thereby efficiently heating the outer surface 20. Therefore, the interior 50 of the mass concrete 10 is cooled by means of the cooling water 60 flowing along the pipes 120, and the outer surface 20 of the mass concrete 10 is heated by means of the heated cooling water being discharged through the holes 310 of the hoses 300, thereby reducing a temperature difference from the interior 50 to the outer surface 20 of the mass concrete 10.

The heated cooling water being discharged through the holes 310 of the hoses 300 gathers to the water recovery ducts 400 and is returned to the main water reservoir 100 through the water recovery pipes 130 (at step S90-2). Also, the water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further

provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130. The circulation is kept until the temperature of the interior 50 of the mass concrete 10 is less than the set temperature.

5 In the intermediate step of the curing process, further, if the temperature of the interior 50 of the mass concrete 10 is less than the set temperature (for example, about 50°C), it is too low to heat the supplied cooling water anymore, thereby stopping heating the outer surface 20. Therefore, if
10 the temperature of the interior of the mass concrete 10 is less than the set temperature (at step S100-2), the operations of the first pumps 110 stop by the control of the control unit 600 to shut off the supply of the cooling water 60 to the pipes 120 (at step S110-2). Further, the second
15 pumps 730 and the switching valves 720 are operated by means of the control unit 600 to shut off the connected portions between the pipes 120 and the hoses 300, while the connected portions between the supply pipes 710 and the hoses 300 are being open. Accordingly, the heated water 61 stored in the
20 auxiliary water reservoir 700 is supplied through the supply pipes 710 (at step S120-2).

The heated water 61 is supplied to the hoses 300 through the supply pipes 710 and is discharged through the holes 310 (at step S130-2). Accordingly, the heated water 61 is
25 supplied to the outer surface 20 of the mass concrete 10, thereby heating the outer surface 20 of the mass concrete 10 (at step S140-2).

Also, the auxiliary water reservoir 700 has the heating means 500 mounted therein and keeps the stored heated water
30 61 to a temperature in a range between 40°C and 70°C. Therefore, the heated water 61 stored in the auxiliary water reservoir 700 is supplied to the hoses 300 through the supply

pipes 710 and is discharged through the holes 310, thereby heating the outer surface 20 of the mass concrete 10. The heating water 61 supplied to the outer surface 20 is absorbed to the curing blanket 200, and the rest thereof gathers to the water recovery ducts 400. Next, the heating water 61 is collected to the main water reservoir 100 through the water recovery pipes 130 connected to the water recovery ducts 400. The water recovery pipe 130 is disposed to connect a position where the heated cooling water gathers and the main water reservoir 100, and the water recovery pump may be further provided to collect the heated cooling water to the main water reservoir 100 through the water recovery pipe 130.

The connection pipe 740 is provided between the auxiliary water reservoir 700 and the main water reservoir 100. Thus, the cooling water 60 stored in the main water reservoir 100 is supplied to the auxiliary water reservoir 700, and the heated water 61 heated by means of the heating means 500 mounted inside the auxiliary water reservoir 700 is supplied to the outer surface 20 of the mass concrete 10 through the supply pipes 710. The circulation starts at the time when the temperature of the interior 50 of the mass concrete 10 is less than the set temperature and is kept until the curing process is completed (at step 150-2). After the curing process for the mass concrete 10 is completed, finally, the pipes 120 are filled by means of grouting to finish the formation of the mass concrete 10.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by the embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

Claims

【Claim 1】

An apparatus for reducing a temperature difference generated in mass concrete made by assembling iron bars, setting up a form and pouring concrete into the form, during a curing process of the mass concrete, the apparatus comprising:

a main water reservoir adapted to store cooling water therein;

pipes disposed inside the form in such a manner as to be buried in the interior of the mass concrete at the time of concrete casting, the pipes being spaced apart from each other by a given distance in such a manner as to be passed through the mass concrete and being connected to the main water reservoir from which the cooling water is supplied thereto, so that the temperature of the interior of the mass concrete is decreased and the cooling water supplied thereto is heated to discharge heated cooling water therefrom;

hoses disposed on the outer surface of the mass concrete in such a manner as to be connected to the output ends of the pipes from which the heated cooling water is supplied thereto, each hose having a plurality of holes formed on the outer periphery thereof, through which the heated cooling water is discharged;

an auxiliary water reservoir adapted to store heated water therein;

supply pipes connected to the auxiliary water reservoir to supply the heated water to the outer surface of the mass concrete if the temperature of the interior of the mass concrete is less than a set temperature; and

a control unit operated to supply the cooling water from the main water reservoir to the pipes if the temperature of the interior of the mass concrete is more than a set temperature and to supply the heated water from the auxiliary water reservoir to the supply pipes if the temperature of the interior of the mass concrete is less than the set temperature,

the apparatus further comprising:

switching valves mounted at positions where the output ends of the supply pipes are disposed between the pipes and the hoses to shut off the supply of the cooling water, while

supplying the heated water to the hoses through the supply pipes, if the temperature of the interior of the mass concrete is less than the set temperature,

water recovery ducts disposed along the edges of the mass concrete so as to collect the heated cooling water or the heated water flowing along the outer surface of the mass concrete through the discharging from the plurality of holes of the hoses disposed on the outer surface of the mass concrete; and water recovery pipes connected to the water recovery ducts to collect the heated cooling water or the heated water to the main water reservoir,

water passages formed along the edges where the mass concrete and the ground meet each other to collect the heated cooling water or the heated water thereto; and water recovery pipes connected to the water passages to collect the heated cooling water or the heated water to the main water reservoir, and

water recovery pipes adapted to connect a position where the heated water or the heated cooling water gathers to the main water reservoir; and water recovery pumps provided to collect the heated water or the heated cooling water to the main water reservoir through the water recovery pipes,

first pumps disposed between the main water reservoir and the pipes to supply the cooling water to the pipes; and

second pumps disposed between the auxiliary water reservoir and the supply pipes to supply the heated water to the supply pipes.

【Claim 2】

The apparatus as defined in claim 1, further comprising a curing blanket covered on the outer surface of the mass concrete to absorb a portion of the heated cooling water or the heated water being discharged through the holes, thereby allowing the absorbed heated cooling water or the absorbed heated water to be contacted with the outer surface of the mass concrete.

【Claim 3】

The apparatus as defined in claim 2, further comprising a heat-retaining member covered on the curing blanket to keep the heat of the heated cooling water or the heated water absorbed to the curing blanket.

【Claim 4】

The apparatus as defined in claim 3, wherein the heat-retaining member is formed of vinyl canvas or bubble sheets.

【Claim 5】

The apparatus as defined in claim 1, wherein the auxiliary water reservoir comprises heating means adapted to heat the heated water stored thereinto.

【Claim 6】

The apparatus as defined in claim 5, further comprising a surface portion temperature sensor disposed on the outer surface of the mass concrete to measure the temperature of the outer surface and a center portion temperature sensor disposed in the interior of the mass concrete to measure the temperature of the interior of the mass concrete, wherein the control unit is connected to the heating means to supply power to the heating means and operates the switching valves if the temperature of the interior of the mass concrete obtained from the center portion temperature sensor is less than the set temperature, so that the supply of the heated cooling water from the pipes to the hoses stops and the heated water from the supply pipes to the hoses is supplied.

【Claim 7】

The apparatus as defined in claim 6, further comprising a connection pipe provided between the auxiliary water reservoir and the main water reservoir to supply the cooling water stored in the main water reservoir to the auxiliary water reservoir.

【Claim 8】

The apparatus as defined in claim 6, wherein the control unit controls the first pumps to adjust the flow rate of the cooling water being supplied to the pipes and the second pumps to adjust the flow rate of the heated water being supplied to the hoses.

【Claim 9】

The apparatus as defined in claim 8, wherein the temperature difference from the interior to the outer surface of the mass concrete is calculated by the control unit, and if the temperature difference calculated by the control unit is more than the set temperature difference, the first pumps are operated to supply the cooling water to the pipes.

【Claim 10】

A method for reducing a temperature difference generated in mass concrete, the method comprising the steps of:

assembling iron bars, setting up a form, and disposing at least one or more pipes inside the form in such a manner as to be passed through the mass concrete built by casting concrete in the form;

disposing at least one or more hoses, each having a plurality of holes formed on the outer periphery thereof, on the outer surface of the mass concrete, connecting the other side ends of the pipes to the hoses and one side ends of the pipes to a main water reservoir into which the cooling water is stored; and disposing an auxiliary water reservoir in which heated water is stored and supply pipes adapted to supply the heated water to the outer surface of the mass concrete;

disposing water recovery ducts on the sides of the mass concrete or forming water passages on the edges where the mass concrete and the ground meets each other;

supplying the cooling water stored in the main water reservoir to the pipes by means of first pumps, when the temperature difference from the interior to the outer surface of the mass concrete is generated;

cooling the interior of the mass concrete by the cooling water supplied to the pipes and supplying the heated cooling water to the hoses;

discharging the heated cooling water through the holes of the hoses to heat the outer surface of the mass concrete, collecting the heated cooling water to the water passages or the water recovery ducts, returning the heated cooling water to the main water reservoir through water recovery pipes connected to the water passages or the water recovery ducts and water recovery pumps mounted on the water recovery pipes; and

if the temperature of the interior of the mass concrete is less than a set temperature, stopping the operations of the first pumps by a control unit to shut off the supply of the cooling water supplied to the pipes, operating second pumps disposed between the supply pipes and the auxiliary water reservoir by the control unit to supply the heated water to the outer surface of the mass concrete through the supply pipes,

wherein the step of disposing the supply pipes further comprises the step of disposing switching valves between the pipes and the hoses in such a manner as to be connected to the supply pipes, and the step of supplying the heated water to the outer surface of the mass concrete further comprises the steps of operating the switching valves by the control unit to shut off the supply of the cooling water supplied to the pipes and supplying the heated water to the hoses through the supply pipes if the temperature of the interior of the mass concrete is less than the set temperature,

further comprising the step of supplying power to heating means mounted inside the auxiliary water reservoir by the control of the control to heat the heated water,

wherein the flow rate of the cooling water being supplied to the pipes and the flow rate of the heated water being supplied to the supply pipes are adjusted by the control unit, and

wherein the temperature difference from the interior to the outer surface of the mass concrete is calculated by the control unit, based upon the temperatures of the outer surface and the interior of the mass concrete obtained from a surface portion temperature sensor disposed on the outer surface of the mass concrete and a center portion temperature sensor disposed in the interior of the mass concrete, so that if the temperature difference calculated by the control unit is more than the set temperature difference, the first pumps are operated.

【Claim 11】

The method as defined in claim 10, wherein the step of disposing the supply pipes further comprises the step of disposing a curing blanket on the outer surface of the mass concrete, so that the curing blanket absorbs a portion of the heated water discharged through the plurality of holes of the hoses thereto, in the step of collecting the heated cooling water.

【Claim 12】

The method as defined in claim 11, wherein after the step of disposing the curing blanket, a heat-retaining member is covered on the curing blanket.

【Claim 13】

The method as defined in claim 10, wherein before the step of supplying the heated water to the outer surface of the mass concrete, a connection pipe is disposed between the main water reservoir and the auxiliary water reservoir to supply the cooling water stored in the main water reservoir to the auxiliary water reservoir.

【Claim 14】

The method as defined in claim 13, wherein after the curing process of the mass concrete is completed, the pipes are filled by means of grouting.

【Claim 15】

The mass concrete cured by the method as defined in claim 10.