

Dec. 9, 1958

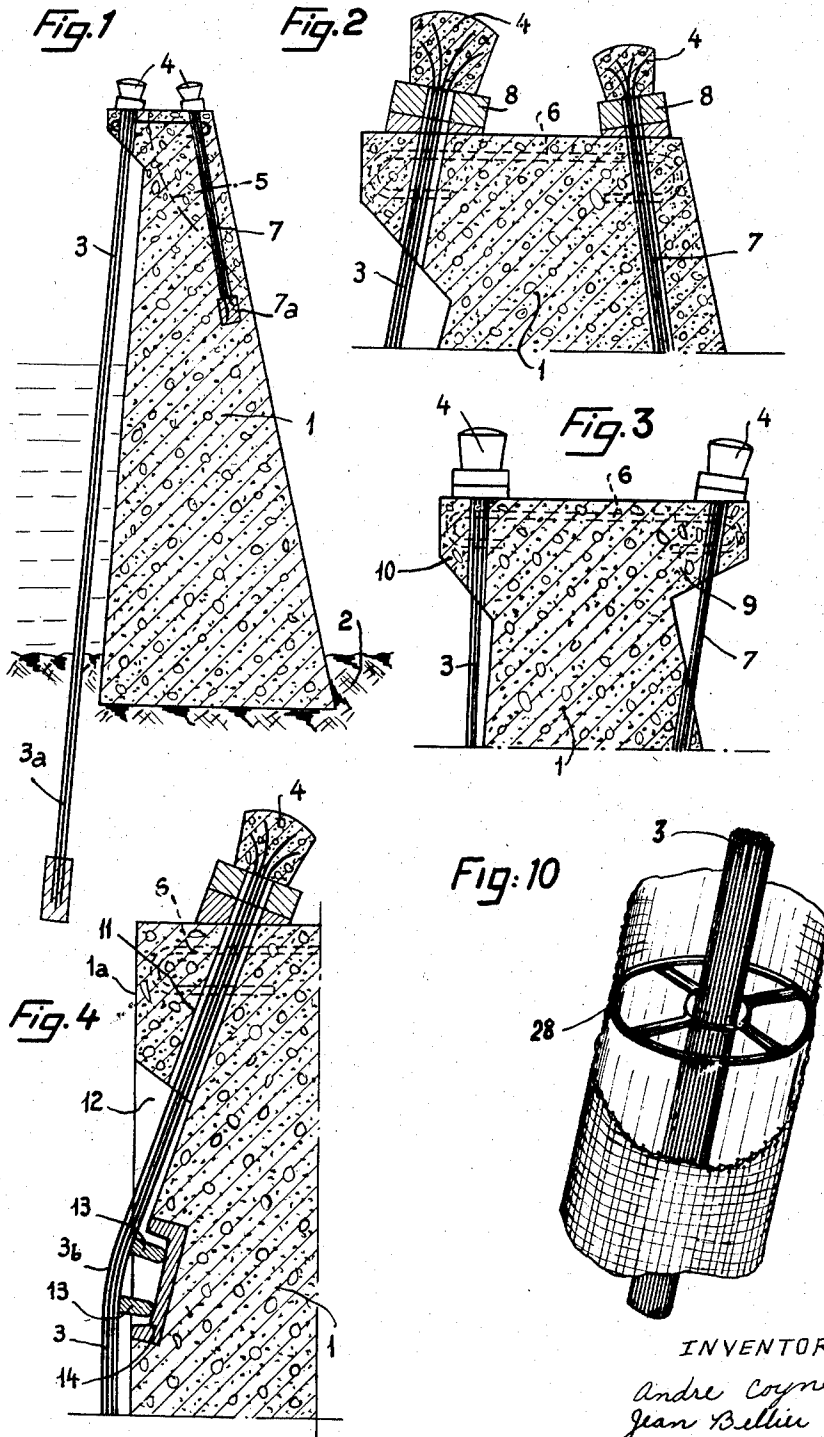
A. COYNE ET AL

2,863,292

REINFORCED AND STABILIZED DAM STRUCTURE

Filed Jan. 27, 1953

2 Sheets-Sheet 1



INVENTORS

Andre Coyne

Jean Bellin

By Watson, Cole, Brundage &
Watson ATTORNEYS

Dec. 9, 1958

A. COYNE ET AL

2,863,292

REINFORCED AND STABILIZED DAM STRUCTURE

Filed Jan. 27, 1953

2 Sheets-Sheet 2

Fig: 7

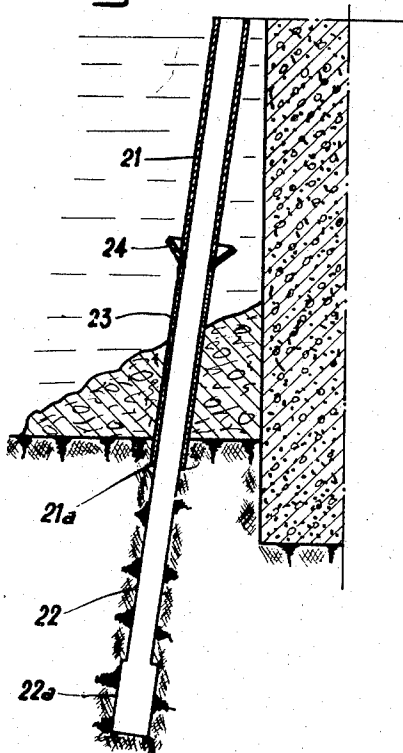


Fig: 8

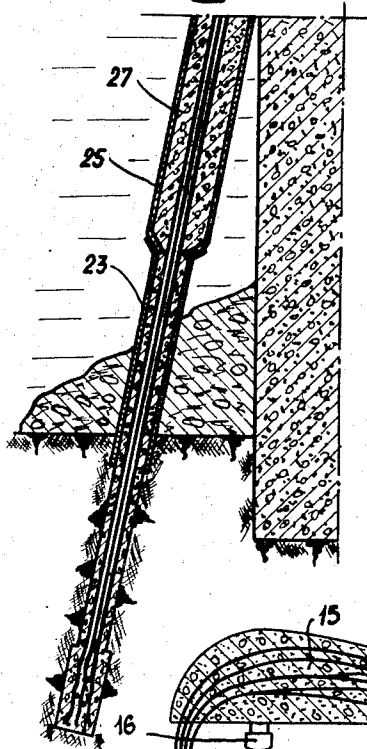


Fig. 5

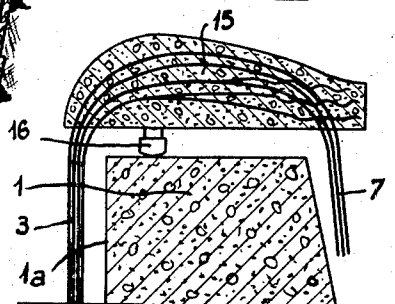


Fig: 9

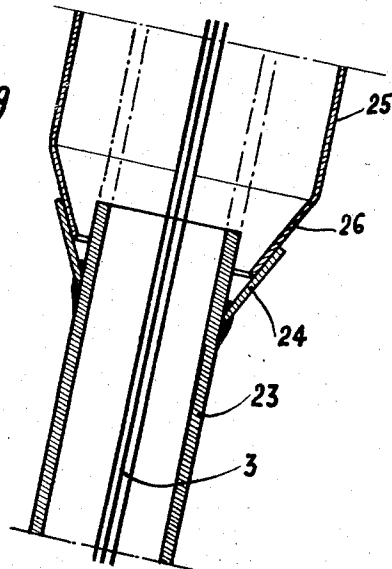
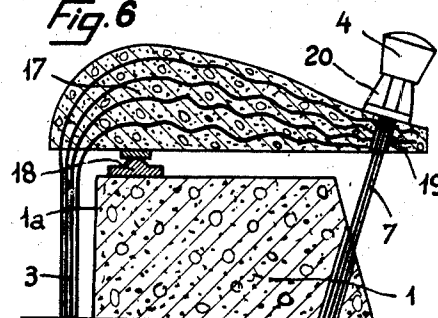


Fig. 6



INVENTORS

Andre Coyne
Jean Bethier
By Watson, Cole, Grindle
& Watson ATTORNEYS

1

2,863,292

REINFORCED AND STABILIZED DAM STRUCTURE

André Coyne and Jean Bellier, Paris, France

Application January 27, 1953, Serial No. 333,551

2 Claims. (Cl. 61—33)

It has already been suggested to reinforce and stabilize a structure by exerting forces judiciously applied to it through the medium of high-powdered braces anchored in the ground.

In known forms of embodiment of this method, each tie-member is received in a hole pre-formed or formed in the structure and extended into the ground for the purpose of anchoring the tie-rod. Where it is proposed to strengthen an existent structure, the drilling of the holes required for the passing of the cables constituting the braces is expensive and constitutes by far the lengthiest part of the reinforcing operation. The provision of holes in a new building likewise complicates the work and may increase the expense.

The present invention has for its object to provide a method of reinforcing and stabilizing a structure designed to avert, or at any rate minimize, the necessity of drilling holes in the structures. The method is particularly applicable to dams found to have an inadequate cross sectional profile, in which case the method provides additional advantages as will presently appear.

The method of the invention consists of arranging one or more main tie-members or braces adjacent to and externally of one face of the structure, the lower end of the brace or braces being anchored in the ground and the other end, which exerts the tension force, being anchored on the upper part of the structure; the bending moment on said upper part due to the eccentricity of the said brace or braces being compensated for by means of ordinary reinforcements or of one or more secondary braces secured, at one end, to the said upper part of the structure, on the side opposite from the main braces and being anchored, at the other end, at a variable depth in the structure itself.

In the particular instance of dams, the main tensioned braces are arranged in front and externally of the upstream face of the structure over at least a major part of its height, while the excessive bending moments which they would be liable to produce towards the crest of the dam are compensated for by means of ordinary reinforcements or secondary tensioned braces placed on the downstream side and anchored at a suitable depth within the work itself, which latter braces may extend partially outside the dam.

In this way, it no longer is necessary in order to reinforce a structure, such as a dam, by braces to provide within the dam perforations of great length, equalling the entire height of the dam in addition to the necessary depth of anchorage in the ground.

The secondary braces on the other hand will require the drilling of holes of a certain length in the structure, e. g., a dam, but the diameter of such holes is smaller and their length much less than the height of the dam.

This is true because the torque exerted on the dam by the force of the main braces will, in general, be capable of exerting objectionable effects only in the upper part of the work. At lower levels, the weight of the upper part of the structure and the cross sectional area of

2

masonry will be sufficient to make the being-compensating effect ensured by the secondary braces unnecessary. The critical level thus determined will simultaneously provide the level at which the secondary braces should be anchored.

Below this level, the successive cross-sections of the structure are exclusively subjected to the action of the main braces, more suitably located for the creation of a compensating moment than if they were placed within the structure especially in the case of a dam. Hence, an additional saving is accessorially obtained on the proportion of prestress required to ensure the equilibrium of the structure.

The main and secondary braces may be placed in tension individually. However, it may be desirable to place a main brace and the corresponding secondary brace or braces simultaneously under tension, by securing both these kinds of braces to the opposite ends of a common member acting as a lever, which member is forced upwards by means of suitably disposed jacks so as to impose the same degree of strain to both kinds of braces, and is then carefully blocked on the coping of the structure in such a way as not to alter the distribution of strains.

The levers used for this purpose are preferably concrete. They may desirably be prefabricated and, preferably, are reinforced with the very wires of the cables attached to them.

In connection with dams, special attention must be paid to the protection of the braces thus arranged on the upstream side against corrosion. To this end, the brace in its final condition is surrounded with a tube or a casing having its lower end engaged in the ground if necessary extending through any layer of mud, silt and blocks which may be deposited at the foot of the dam. This part of the brace casing may be formed by the same tubing as that which served as a guide for the drilling operation, and which originally is normally extended up to the operating platform located at the top of the dam.

After the brace has been introduced and grouted in its hole through the first said tubing, the free part of the tube, if not all of it, may be recovered and replaced with a thin sheet metal lining, or shuttering, or even with a simple cylindrical canvas lining which does not even require to be waterproof. The brace is put under tension and the lining is then filled with cement, mortar or concrete, slightly reinforced if necessary in the ordinary way, in order to provide a permanent protection for the prestressing steel.

The ensuing description made with reference to the accompanying drawings, given by way of example and not of limitation, will clearly show how the invention can be carried into practice.

Fig. 1 is a diagrammatical vertical cross-section of a dam reinforced and stabilized according to the present invention.

Fig. 2 illustrates in a similar sectional view on an enlarged scale, the crest of the dam.

Fig. 3 is similar to Fig. 2 and shows in section a modified construction of the crest of the dam.

Fig. 4 shows the upstream facing of a dam in another modification of the invention, the view being a vertical cross-section near the crest.

Figs. 5 and 6 illustrate cross sectional views similar to Figs. 2 and 3 illustrating crests of dams wherein the main and secondary braces are rigidly interconnected by means of a lever.

Fig. 7 shows in vertical section a device designed for anchoring a main brace at the foot of a dam.

Fig. 8, similar to Fig. 7, shows a main brace positioned and protected against corrosion, in a final stage of the work.

Figs. 9 and 10 represent details of the corrosion-protecting means for the braces.

As shown in Fig. 1, the dam 1 rests on the ground 2. The dam is assumed to be of insufficient profile and weight for stability by itself. To strengthen and stabilize the dam, a brace or tie-member 3 is anchored at 3a in the ground 2 at the foot of the dam near its upstream facing. The upper end of the brace, provided with an anchoring head 4 is tensioned by means of jacks and is applied against the coping of the structure, for example on a cantilever 10 projecting over from the upstream facing.

The brace 3 which provides means for artificially loading the dam, moreover exerts upon it a moment which opposes the tendency of the dam to be overthrown by the pressure of the water. However the brace applies a bending moment to the top of the dam, that is, tension strains appear in the masonry of the dam substantially in the part thereof located above the broken line 5. In order to offset these strains which might otherwise be excessive, the upper part of the dam is strengthened in the following manner:

Arranged transversely of the crest of the dam are horizontal reinforcements 6 which may or may not be tensioned. These reinforcements may be housed in transversely extending recesses formed in the dam coping and subsequently filled with concrete. Alternatively, the said reinforcements may be imbedded in a concrete girder laid across the dam, or else in an additional height of coping comprising, for example, the cantilevers serving to secure the braces. Moreover, any tendency of the downstream facing of the dam to be strained in tension in its upper portion are counteracted by means of a secondary brace 7 arranged in a perforation formed in the mass of the structure and anchored at 7a, that is at a level lower than that at which excessive tension strains occur in the downstream face of the work.

The brace 7 is, similarly to the brace 3, provided with an anchoring head 4 whereby it can be placed in tension, the tension on the braces being retained after termination of the action of the jacks, by means of blocking shims 8.

In order to increase the efficacy of the brace 7 and reduce the length of drilling required for insertion thereof through the work, a further cantilever 9 may, as shown in Fig. 3, be provided also on the downstream side of the crest.

The degree of eccentricity of the main braces 3 may be reduced and the upstream cantilever may be dispensed with by proceeding as shown in Fig. 4.

Formed at the upper part of the upstream facing 1a are short inclined perforations 11 or recesses or further as shown in the figure, both perforations and recesses providing passages for the braces 3 and bringing their top ends further towards the downstream side. This arrangement may in some cases, for example if the slope of the upstream facing is considerably less than the slope of the braces, make it necessary to bend the latter in the region 3b, the bend being supported by means of pivoted props 13 engaging a suitable support 14 inserted in the structure.

In the construction of Figs. 1 to 4, the main brace 3 and the secondary brace 7 are stretched independently of each other. Both braces may, however, be stretched simultaneously as shown in Figs. 5 and 6.

In the case of Fig. 5, the brace 7 is formed by part of the steel wires or cables constituting the brace 3. The balance of the wire or strands of the brace 3 serves to reinforce a girder 15 serving as a lever, disposed above the crest of the structure. By means of a jack 16 arranged over the crest of the structure near the upstream facing 1a and including means enabling the jack to assume varying inclinations when loaded, the lever 15 is raised above the coping. In this way, the strands 3 and 7 are simultaneously placed under tension. After

this is done, the lever is blocked upon the coping of the structure.

In the embodiment shown in Fig. 6, the strands of the brace 3 all serve as the reinforcement for a girder 17 which rests, through a swivel 18 or equivalent device, upon the coping of the work near the upstream facing thereof. The brace 7, anchored in the downstream face of the work, extends through an opening 19 formed in the end of the lever 17 and is provided with an anchoring head 4. By means of a jack arranged between this anchoring head and the lever, the braces 3 and 7 may be placed under tension as before. After tensioning, the jack is replaced by a blocking shim 20.

It will be observed that, in the case of Fig. 6, the jack is required to be much less powerful than that used in the case of Fig. 5. However, the tensioning displacement is substantially longer, which may require applying several strokes of the jack in succession.

In order to install the reinforcing and stabilizing arrangement of the invention, it is generally required, in the case of a dam, to bore the anchoring hole for the main braces from the coping of the work and in a water-logged site, and moreover, careful protection of the said main braces against corrosion is necessary in view of their permanent immersion and the difficulty of subsequently checking their condition. These results may be obtained in the manner diagrammatically illustrated in Figs. 7 and 8.

In order to drill an anchoring well at the foot of the structure a rigid tube 21, adapted to serve as a guide for the drilling apparatus, is installed from the working platform at the crest of the work. The end 21a of the tube is driven, with a pile driver or by rotation, through the silt, deposits or stone bedding lying at the foot of the dam, down to the natural subsoil in which it is sealed. The shaft 22 is then bored in the ground and its base may be enlarged as at 22a in a known manner in order to improve the anchoring of the extremity of the brace. After the shaft has been drilled, the brace may be lowered into it through the rigid tube and the latter may be retained in place to be subsequently filled with cement so as to protect the brace against corrosion.

It is desirable, however, to recover all or part of the rigid tube for making further anchoring shafts which are required along the length of the dam. For this purpose, as shown in Fig. 7, the tube 21 preferably is provided with a separable end 23 the length of which will be determined by the depth of the bedding piled at the foot of the dam. This terminal portion 23 is rigidly connected, e. g. by an interfitting or a screw joint, with the tube 21 proper which may in turn be made of a plurality of inter-assembled parts. Near the upper part the tube section 23 is formed with an outwardly flaring flange or collar 24.

In order to enable the brace to be coated throughout its length with mortar or other material protecting it against corrosion, while at the same time allowing recovery of the tube 21, the tube 21 is replaced by a much less strongly and accurately constructed and hence more inexpensive tube, such as a tube of thin-gauge metal sheeting 25, which however should be larger in diameter than the tube 21, and the end of which terminates in a frustoconical tip 26 adapted to fit into the flange 24 (Fig. 9). Penetration of the tip 26 into flange 24 is automatically effected owing to the guiding action of the brace 3, or the tube 21 prior to removal thereof, when positioning the tube 25. The free part of tube 21 is then removed and, after the brace has been put in tension, the tube 25 is filled with concrete 27, which, owing to the difference in the diameters of the tubes will act with its entire weight to press the tip 26 into and against the flange 24 and thus provides a tightly sealed final connection.

Instead of a sheet metal tube, a sleeve of waterproof canvas may be used, which may or may not be provided

at its end with the taper connecting 26. Concrete is poured into this sleeve for protecting the braces 3. In order to ensure concentricity between the brace 3 and the canvas sleeve, that is to regularize the depth of the concrete coating protecting the brace, perforated hoops 28 may be threaded over the brace 3 as shown in Fig. 10, the central opening of the hoops being slightly larger in diameter than that of the brace, while the outer diameter thereof is somewhat less than that of the sleeve. With wires fastened to the hoops, the latter can be lowered along the sleeve down to the desired level and then maintained thereat.

It will be understood that modifications may be made in the method and appliance described, and in particular elements therein may be replaced by functionally equivalent ones without exceeding the scope of the present invention.

What we claim is:

1. In combination with a dam having an upstream face and a downstream face, a strengthening and stabilizing arrangement comprising a reinforced concrete element forming a lever fulcrumed at the top of the dam, at least one tensioned brace extending externally of said dam and adjacent to the upstream face thereof, means for anchoring one end of said brace in the ground, means for anchoring the other end of said brace in said element, tensioned reinforcing means associated with

said brace and adjacent to the downstream face of said dam, for opposing the bending moment exerted on the upper part of the dam by the tensioned brace, means for anchoring one end of said reinforcing means within the dam, and means for anchoring the other end of said reinforcing means in said element, said brace and said reinforcing means being anchored in said element on both sides of the fulcrum of said lever and said fulcrum being nearer the brace than the reinforcing means.

2. The combination of claim 1 wherein the brace and reinforcing means are simultaneously tensioned through action of the lever.

References Cited in the file of this patent

UNITED STATES PATENTS

903,909	Steiner	Nov. 17, 1908
1,896,810	Coyne	Feb. 7, 1933
2,128,657	Madaras	Aug. 30, 1938

FOREIGN PATENTS

556,572	Great Britain	Oct. 11, 1943
---------	---------------	---------------

OTHER REFERENCES

"Linear Prestressed Concrete Construction," by C. C. Zollman, published in "The Military Engineer," November-December, 1952, pages 432-439.