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(71) Applicant: **Chiaves, Carlo**
10129 Torino (IT)

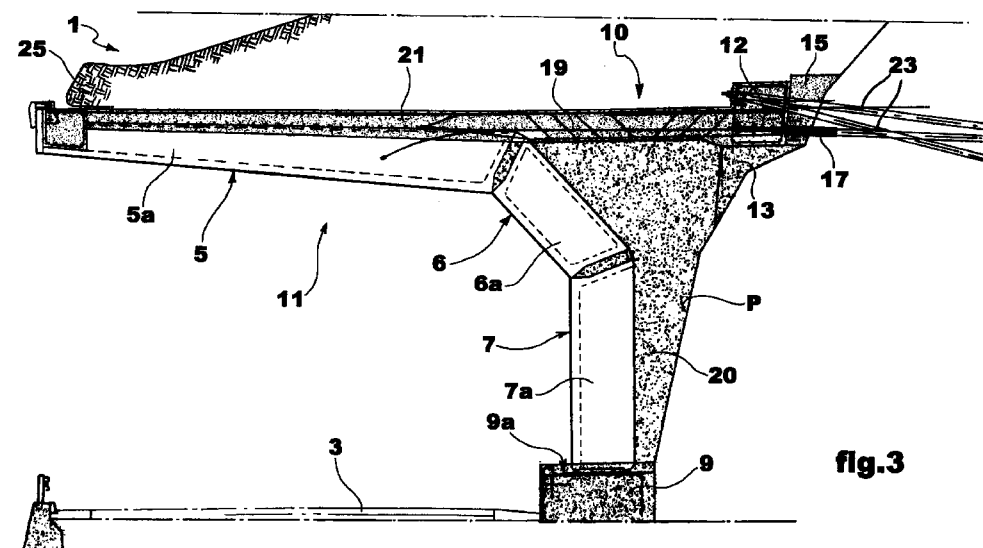
(72) Inventor: **Chiaves, Carlo**
10129 Torino (IT)

(74) Representative: **Cian, Paolo et al**
Jacobacci & Perani S.p.A.
Corso Reggio Parco 27
10152 Torino (IT)

(54) **Cantilevered structure for the protection of a communication route**

(57) A cantilevered structure for the protection of a communication route includes a covering part (5) which extends above the communication route (3) and is connected to the slope (P) uphill of the communication route (3) by means of a support structure (10). The covering part (5) is associated with a pier (7) arranged in proximity to the slope (P). Between the covering part (5) and the pier (7) is interposed a connecting part (6) rigidly connected to the covering part (5) and to the pier (7)

so as to transmit to the pier (7) a bending moment acting on the covering part (5). The chord of the connecting part (6) is inclined both with respect to the covering part (5) and with respect to the pier (7) so as to form an obtuse angle with each of the latter. The covering part (5) is anchored to the slope (P) by means of a reinforced concrete slab (21).



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Description

[0001] The present invention relates to structures for the protection of communication routes such as roads, railways or canals constructed on a hillside, against rockfalls, landslides or avalanches.

[0002] At present, for this purpose artificial tunnels are used with arc-shaped or portal-like section, the vault of which constitutes the structure for protecting the communication route.

[0003] Artificial tunnels of this type have various drawbacks, however. Firstly, their structure is generally not very deformable and therefore fragile, and thus not very suitable for withstanding without damage the impacts due to bodies having a large mass, such as rocks, falling from considerable heights. Nor are they very suitable for withstanding horizontal forces and large asymmetrical loads, such as, for example, those arising from landslides of extensive dimensions.

[0004] In order to produce conventional artificial tunnels on pre-existing communication routes it is always necessary to interrupt the traffic for the entire duration of the construction work.

[0005] In many cases, the artificial tunnels are provided with windows in the downhill wall, constituted by a series of apertures which permit daylight illumination of the communication route. However, because of the alternation of openings and walls or pillars, inside the tunnel there is an alternation of light and shadow which is harmful to the safety of the traffic.

[0006] In an endeavour to remedy the drawbacks of the conventional artificial tunnels, for some time the use of cantilevered or bracket structures has been proposed for purposes similar to artificial tunnels, but for generally much less onerous applications.

[0007] Cantilevered covering structures, if sufficiently robust, are preferred to artificial tunnels even with windows, both because they have a lesser environmental impact and because they eliminate the problem of alternating light and shadow on the communication route. Moreover, they do not require pillar foundation works on the downhill side of the site, which works are usually complex in so far as they have to be founded on a slope which often proves to be unsuitable for carrying loads inclined downhill. Moreover, even if they are structurally less resistant with regard to static vertical loads, they are much more resilient than the tunnel structures and therefore more suitable for supporting without damage substantial deflections resulting from localized impacts caused by rockfalls.

[0008] However, known cantilevered structures have the serious drawback of requiring very firm tie-rod anchoring structures, the provision of which is very costly, in order to make it possible to obtain a strength of the structure which is not too inferior to that of an artificial tunnel, and therefore in order to be able to satisfy the safety requirements of the site in the various environmental conditions. It is further known that cantilev-

ered structures anchored by means of tie-rods, if subjected to high forces, are not very reliable and therefore generally dangerous.

[0009] In order to eliminate these drawbacks, the subject of the invention is a cantilevered structure for the protection of a communication route, of the type indicated in the appended claim 1.

[0010] By means of such a solution concept it is possible to obtain a structure having the function of a very resilient artificial tunnel for protection against rocks, which is capable of withstanding substantial deflections so as to have a large reserve of deformation before giving way, with full advantage of strength in the face of localized impacts. The structure proposed is in particular suitable for withstanding much greater deformations than those that can be withstood by conventional cantilevered structures, owing to the fact that its pier and its connecting part also participate in the deformation of the entire structure, reducing the rate of deformation due to the covering alone. In fact, following an impact due to the fall of a rock, the bending moment which stresses the fixed end of the cantilevered covering is transmitted also to the connecting part and to the pier which, in turn, deform and increase the deflection of the point of impact. Therefore, with equal work of the force of impact, the deformations arising on the covering are much reduced with respect to those which arise on a conventional type cantilevered structure.

[0011] Moreover, the structure according to the invention requires the production of a system of tie-rods which is much more modest than that necessary for the known cantilevered structures in so far as, unlike these, it has an arm for resisting the bending moment of the cantilevered part, constituted by the entire height of the structure, while in the conventional cantilevered structures the resistance to the bending moment is equal to or not much greater than the arm of the internal couple of the fixed end section of the cantilever. In this way, the force of the utilization of the tie-rods necessary for the stability of the work can be drastically reduced, so that either the system of tie-rods is more economical to produce, or with the same number of tie-rods the work is significantly safer, the tie-rods being subjected to relatively smaller loads.

[0012] The structure proves to be particularly resistant to asymmetrical loads generated by the successive accumulations of earth-rock material on the uphill side of the structure as a result of landslides characterized by non-instantaneous movements of considerable volumes of material.

[0013] The structure then has the advantage of not requiring pillars on the downhill side, thus rendering it aesthetically pleasing and reducing the impact on the environment, and further permitting uniform illumination of the communication route and therefore optimum visibility.

[0014] To produce the structure according to the invention, much shorter times are necessary than those

required by known artificial tunnels, and this constitutes a considerable advantage. In fact, the construction work consists essentially of the mounting, in succession, of prefabricated reinforced concrete units constituting successive short sections of the structure, and anchoring them to a support structure fixed to the slope. In this way it is not necessary to form a permanent building site, but the construction work can be carried out at daily rhythmic intervals, for example only at night, with minimum disturbance to traffic.

[0015] When the prefabricated structure has been erected, the remaining works are carried out above the structure, which is already in its stable configuration, in such a manner that the communication route remains free, so that it is possible to travel over at least part of it.

[0016] Further characteristics and advantages of the invention will become clear from the following detailed description, provided simply by way of non-limiting example with reference to the appended drawings, in which:

Figure 1 is a view in side elevation of a structure according to the invention in a first phase of execution,

Figure 2 is an enlarged view of a detail indicated by the arrow II in Figure 1, and

Figure 3 is a view similar to Figure 1 in a successive phase of execution of the structure of the invention.

[0017] With reference to the drawings, the reference 1 indicates as a whole a cantilevered structure intended to protect a communication, route 3 against landslides, avalanches or rockfalls.

[0018] The structure 1 comprises a rectilinear cantilevered covering part 5 and a substantially vertical support part or pier 7, also rectilinear, which constitutes a portion of side wall. In particular, the structure 1 is produced in the form of a plurality of contiguous prefabricated units placed side by side, each of which extends for an axial portion of the work.

[0019] Between the covering part 5 and the pier 7 is interposed a connecting part 6 which is rigidly connected to the corresponding ends of the parts 5 and 7 and is structurally of such dimensions as to support almost all the fixed end bending moment of the covering part 5. The part 6 may be arcuate in shape, straight or in the shape of a broken line, but its chord, or the notional line which joins its ends for connection to the parts 5 and 7, is in each case inclined so as to form an obtuse angle both with the part 5 and with the part 7.

[0020] The various sections of the structure 1 bear on a continuous foundation casting 9 produced previously on site in a manner which is known *per se*, and are anchored to the slope P uphill of the communication route 3 by means of a support structure 10, as will be explained in the continuation of the description.

[0021] Each section of the structure 1 preferably includes an articulated prefabricated unit 11 of rein-

forced concrete, for example of the type described in European Patent Application EP-A-219 501.

[0022] Each of the prefabricated units 11 comprises in particular three bodies connected to one another by means of reinforcement rods at two areas of articulation, or rather, a bracket body 5a, rectilinear in shape and slightly tapered towards its free end, intended to constitute an axial section of the covering part 5 of the structure 1, an upright or column body 7a defining an axial section of the pier 7, and an intermediate body 6a capable of constituting an axial section of the connecting part 6 of the structure 1.

[0023] The column body 7a conveniently has a thickness equal to, or slightly less than, that of the bracket body 5a. It is strongly reinforced at the side facing the slope P by means of reinforcing bars constituted by the extension of the reinforcement of the relative body 5a, so that the bending moment which stresses the body 5a in the fixed end section can easily be withstood both by the intermediate body 6a and by the column body 7a of the unit 11. The body 6a has in particular a not negligible extension with respect to that of the bracket body 5a, for example equal to at least 1/20th of the length of the body 5a.

[0024] The articulated prefabricated units of the type indicated above have the advantage of being able to be produced in a flat configuration so as to be able to be transported easily in the extended state from the production premises to the construction site. While being installed on site, they are lifted by means of special equipment in such a manner that, by the effect of their weight, the reinforcing rods bend during lifting, at the areas of articulation between the various bodies, so that the entire unit 11 automatically assumes its final configuration of an inverted L-shape, bevelled at the intermediate body 6a.

[0025] These articulated prefabricated units guarantee the complete continuity of the reinforcements in all the tensioned parts of the finished product, the precise on site placing of the reinforcements, and simple and rapid operations of installation of the product on site.

[0026] Once installation on site has taken place, the areas of articulation between the bodies of the unit 11 are blocked with concrete sealing castings and with the incorporation of additional reinforcement.

[0027] The unit 11 bears, with the opposite end of the column body 7a from the body 6a, on the foundation casting 9, by way of a respective static hinge 9a of the type described in European Patent Application EP-A-861 358, produced at the lower edge of the body 7a intended to be turned towards the communication route 3. The hinge 9a, in summary, comprises a part consisting of a hollow cylindrical appendage integral with the body 7a and of another hollow part corresponding to the cylindrical appendage of the body 9a and connected to the foundation 9, produced on site by casting concrete between the foundation 9 and the unit 11 when the unit

11 is bearing on the foundation. Preferably, between the cylindrical appendage and the corresponding hollow seat of the static hinge 9a there is interposed a layer of anti-friction material, for example consisting of a sheet of high density polyethylene or another deformable plastics material, having a low coefficient of friction with respect to concrete, in order to facilitate relative rotation between the body 7a and the foundation 9.

[0028] After each unit 11 has been brought into its erect position, or after it has assumed its final configuration of an inverted L-shape, it is stabilized by connecting it to a common anchoring structure 12 fixed to the slope P.

[0029] The anchoring structure 12 is arranged before the mounting of the units 11 by forming on the slope P a kerb 13 having the function of a regularizing casting, and a head beam 15 above the kerb 13. The beam 15 is then perforated at predetermined intervals in order to insert into it and into the wall of the slope P a plurality of tie-rods 17. To the free end of the tie-rods 17 there is connected by means of screw nuts 17a a mooring or fixing beam consisting of a pair of U-profile sections 18 which are opposed and slightly spaced from each other so as to define an intermediate space between them, the profile sections 18 being connected to each other at the webs by means of drilled plates 18a.

[0030] When each of the units 11 has assumed the erect position illustrated in Figure 1, it is connected to the anchoring structure 12 by means of retaining members 19 working under tension, consisting for example of a pair of screw-threaded bars for each unit 11, which extend from the relative bracket body 5a in proximity to the area of articulation to the intermediate body 6a. The retaining members 19 are inserted between the pair of profile sections 18 so as to engage the space between them and are locked with respect to the mooring beam by means of clamping nuts 19a.

[0031] Each prefabricated unit 11, after its installation on site and its connection to the anchoring structure 12, is completely stabilized. It is therefore possible both to carry out the on site castings for consolidation of the unit 11 at the areas of articulation between the bodies 5a, 6a and 7a, and to cast concrete at the base of the unit 11, above the foundation 9, to form the relative part of the static hinge 9a.

[0032] When all the units 11 of the structure 1 have been arranged and connected to the anchoring structure 12, the gap between the units 11 and the slope P is filled with compacted granular material 20 (see Figure 3).

[0033] At this point the structure 1 can be finally fixed to the slope P by producing on site a substantially horizontal slab 21 of reinforced concrete, optionally prestressed, having the function of a tie-beam, at the upper outer surface of the bracket body 5a, in such a manner as to incorporate also the anchoring structure 12 in the slab 21.

[0034] The slab 21 also has the function of interconnecting the various prefabricated units 11 in such a manner as to render them integral with one another and of finally securing the units 11 to the tie-rods 17 and, by way of the latter, anchoring the entire structure 1 to the wall of the slope P.

[0035] In order further to secure the slab 21 to the slope P, a series of additional tie-rods 23 is further arranged so as to traverse a part of the slab 21 in proximity to the slope P and the head beam 15.

[0036] Above the structure 1 thus obtained there is then formed a covering embankment 25 arranged in a configuration inclined downhill.

Claims

1. A cantilevered structure for the protection of a communication route, including a covering part (5) which extends above the communication route (3) and is connected to the slope (P) uphill of the communication route (3) by means of a support structure (10), in which the covering part (5) is associated with a pier (7) arranged in proximity to said slope (P), characterized in that between the covering part (5) and the pier (7) is interposed a connecting part (6) rigidly connected to the covering part (5) and to the pier (7) so as to transmit to the pier (7) the bending moment acting on the covering part (5), the chord of the connecting part being inclined both with respect to the covering part (5) and with respect to the pier (7) so as to form an obtuse angle with each of latter, the covering part (5) being anchored to tie-rods fixed to said slope (P) by means of a slab of reinforced concrete (21).
2. A structure according to claim 1, characterized in that it comprises a plurality of prefabricated reinforced concrete units (11) arranged side by side in succession on top of a foundation casting (9) provided at the base of the site, each of which defines a relative portion of said covering part (5), of said connecting part and of said pier (7).
3. A structure according to claim 2, characterized in that each prefabricated unit is an articulated prefabricated unit (11) which comprises a column body (7a), an intermediate body (6a) and a bracket body (5a) connected to one another by way of at least a part of the main reinforcing rods, each articulated prefabricated unit (11) being installed on site in such a manner as to assume a configuration substantially having a bevelled, inverted L-shape, the column body (7a) bearing on the foundation (9) by means of a concrete casting (9a).
4. A structure according to claim 2 or 3, characterized in that the bracket body (5a) of each prefabricated

unit (11) is connected by way of auxiliary retaining means (19) to a common anchoring structure (12) fixed to said slope (P) by means of anchoring tie-rods (17).

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5. A structure according to claim 4, characterized in that the common anchoring structure (12) comprises a mooring beam (18, 18a).

6. A structure according to claim 4 or 5, characterized in that the bracket bodies (5a) of the prefabricated units (11) are connected to one another by means of said reinforced concrete slab (21) which incorporates said retaining means (19) and said anchoring structure (12).

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7. A structure according to claim 6, characterized in that the slab (21) is anchored to said slope (P) by means of additional tie-rods (23).

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8. A structure according to any one of claims 2 to 7, characterized in that above said slab there is arranged a covering embankment (25) arranged in a configuration inclined downhill.

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