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New Design Concept of Solutions for Dynamic Protection of Canal Lock

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BIOGRAPHICAL NOTES

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KEY WORDS

Canal lock, dynamic protection, boat crash, cable network.

ABSTRACT

Water transport is an integral part of load transport system and therefore its safe functioning is necessary. At waterways the frequent obstacles are hydro-electric power

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plants which are equipped with canal locks to allow the canalisation of the river. To provide safe sailing of ships through such a locks without causing any damage, the canal locks are equipped with a protective system against impact in addition to other devices even in emergencies. This paper describes a proposal of a new construction of the trolley of dynamic canal lock protection as well as a design of its drive.

1. Introduction

The multipurpose water work Gabčíkovo (Fig. 1) has been in operation since October 1992. Eight installed turbines have capacity of 720 MW. Here we can find two canal locks that remind of elevator by their activities and look like great bathtub. Both canal locks are 32 meters high and the maximum difference of water levels, for which they are able to safely perform its function, is 21,6 meters. Its length is 257 meters and width 34 meters. Each can hold 299 200 m^3 of water.

Fig. 1: *Water work Gabčíkovo [3].*

The purpose of the water work Gabčíkovo is mainly to protect against flooding. Waterwork also provides a smooth sailing year-round, provides electricity in a quantity of about 8% of the annual consumption of Slovak Republic, stabilizes the Danube basin and creates conditions for the protection of inland delta of the Danube and recreational opportunities for the development of the adjacent territory. The water works has two canal locks, which ensure smooth ship way that pass through the territory.

2. Dynamic protection of canal lock

An operation of the canal locks on the degree Gabčíkovo must not be affected by any damage of upper or lower gate by vessel, which would damage these operational devices by impact. For this purpose the canal lock is equipped with built-in dynamic protection - equipment for stopping vessels. The stop member comprises of an endless rope, which is guided symmetrically on both sides of the canal lock through the guide and the reverse rollers on the roller of pulley block. The network is lifted up (resp. dropping down) with speed of 1 ms^{-1}, i.e. with the same speed that water level is lifted up (resp. dropping down) in the canal lock when filling (draining). The network working position is 100 mm above the water level in the middle of the canal lock. The braking members are two linear hydraulic motors, one on the each side of the canal lock, which are placed in the supporting column (Fig. 2). On the body of the linear hydraulic motor are two and on the piston rod 3 rollers, that together with a coiled rope create pulley block (Fig. 3).

Fig. 2: *Supporting columns of dynamic protections .*

Each linear hydraulic motor is operated by hydraulic unit. The cable network is pre-stressed by extension of piston rods of linear hydraulic motors to provide capture function. During braking the piston rod is plug in, whereby the value of the braking pressure is given by setting of the bypass valves system.

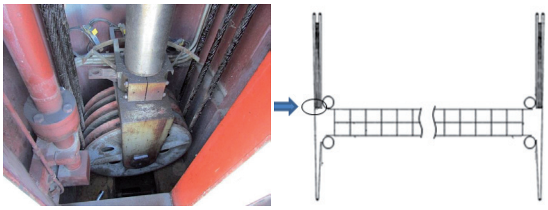

Fig. 3: *Rollers on piston rod of hydraulic motor and arrangement of pulley block network.*

Displacement of the network from working position to position free for ships (lifted net) is performed by reversible rope winch.

Basic parameters of the dynamic canal lock protection are:

Width of canal lock .... 34 m
Length of canal lock .... 257 m
Volume of canal lock .... 299 200 m^3
Depth of canal lock .... 32 m
Max. water level difference .... 21,6 m
Lower gate - pendulous, upper gate - segmental;
The stopping distance .... 8,1 m
Max. vessel speed .... $v = 1\ ms^{-1}$
Impact force of ships to network ... F = 1,58 MN
The pull in the rope .... FL = 0,395 MN
Used rope STN 02 4374 .... ϕ 45 mm
Safety factor .... k = 4.0
Transfer of hoist .... ih = 3
Pre-load of network for free for ships state .... $F_{L2} = 40,5$ kN;

The dynamic protection serves to protect the upper gridiron flaps and gates of canal lock. On steel columns on both sides of the canal locks are mounted trucks in guide rails, through which the cable network is lifted up or dropped down to capture the ships before the upper segment and gates of canal lock. Ropes themselves are attached on rollers and stretched through a set of rollers and hydraulic system. Height of ropes is controlled by means of rope winch.

2.1. Weaknesses of the current solutions and proposal of a new solution

In the guiding of columns the trucks are moving through the sliding friction (Fig. 4). The sliding friction by tight ropes is so high (plus self-weight of the net) that by the release of tension ropes of pulley block trucks remain stuck.

After release of the pulley block ropes, the lifting ropes of hoist (16 mm diameter) are twisted and next lifting is threatened. Pushing of trucks down by pulley block is not possible due to clogging of the bottom rope pulley by gravel and sand. The truck was sliding down under its own gravity when it was still new construction. There are extreme transversal forces from pre-loaded ropes and eccentricity of load and quality of sliding surfaces is considerably degraded by atmospheric exposure.

To eliminate these shortcomings a new construction of the truck (Fig. 5) supported on a flexible rollers (Fig. 6) is designed [1, 2]. There is rolling guide designed instead of sliding guide. A pre-loading of rollers relying on the guiding can be adjusted by usage of cup springs of suspension rollers and thus eliminate transversal forces. The lifting of the whole truck provides endless loop of two-row chain, which is driven by gear motor at the top of the tower (Fig. 7). Both ends of the chain are attached to the truck on the top and on the bottom in the pins of roller brackets. A pre-loading of guide rollers can eliminate to some extent emerging transversal forces influenced by eccentricity of truck load and by unforeseen additional movement resistance. Rolling resistance is small even by stretched ropes, relatively small force is necessary for movement of the trolley. However for lifting of the ropes it is necessary to release ropes on both sides with calculated pre-loading. Truck itself is designed with some gap, which is compensated by sprung front and side guide rollers.

Springing is provided through cup springs inside the body rollers all the way of truck motion. On the Fig.6 we can see the principle of the springing, the green part is solid, the gray part together with the

Fig. 4: *The original design of the truck with slide way, the detail of slide way.*

roller is movable along the pins. The red ones are cup springs, by pressing of which the pre-loading across the roller can be set.

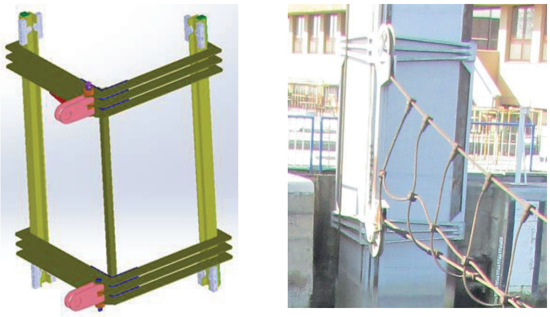

Fig. 5: *The proposed new design of tower truck in the canal lock and the original design.*

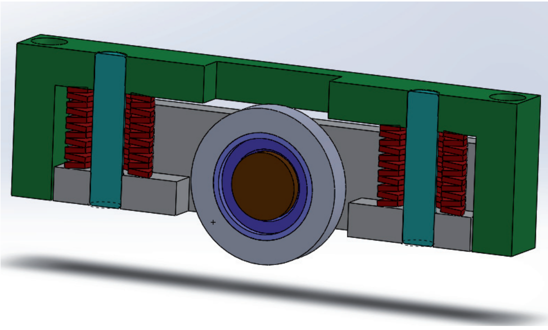

Fig. 6: *Sprung roller.*

The new solution assumes usage of all existing (original) rope pulleys for rope diameter 45 mm, except for the pulley of rope diameter 16 mm. They will be replaced by sprockets and relevant tension and yaw pulleys.

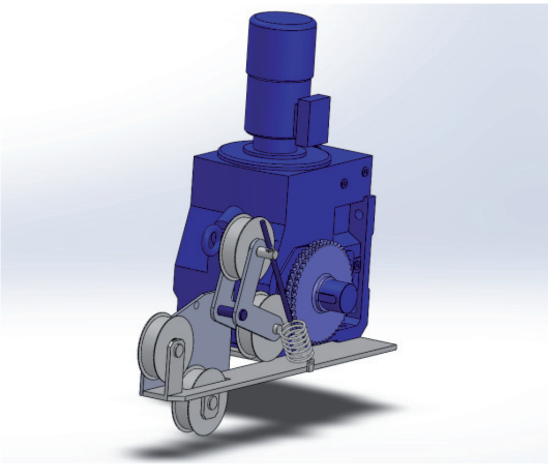

Fig. 7: *Chain drive.*

Fig. 8: *Original roller holder on truck.*

The design of the truck is identical to the original design concept (Fig. 5). It is a welded structure from material with characteristic stress 355 MPa, wherein the two triplets of supporting ribs are connected with rolling section HEM 180 (Fig. 9), in which are mounted the sprung guide wheels with screws [1, 2]. Each trinity of ribs transmit load from one branch of cable network. The design of the truck is adjusted in size so that the whole of the original members of the cable mechanism can be used for the rope of 45 mm. On a truck with two 70 mm diameter pins can be connect the original cable extension (roller holders) (Fig. 8).

One of the requirements of the new design was a proposal to fix the truck in a certain position in the event of maintenance, shutdown or for example equipment failure. For this reason as a drive was designed Geared motors NORD EN 9086,1/52-132S /4 BRE60 FHL WE HR with an output of 5,5 kW and output speed n_2 = 5,6 min^{-1} with M4 mounting positions. An electric motor with brake is used to secure that the network will remain locked in position after lifting switch-off and will not fall down inadvertently. For exceptional cases an electric motor with one more power take (WE) is designed with possibility to attach the wheel (HR) for manual operation (drop down, lift up). At the same time the electric motor has latching handle to the brake (FHL) to not need always press out the brake. In case of device shutdown mechanical stops are designed that are plugged-in to the inside of the tower (Fig. 10). They are fixed in the extended and

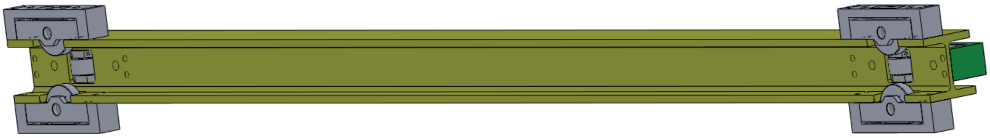

Fig. 9: *HEM 180 with sprung guide wheels.*

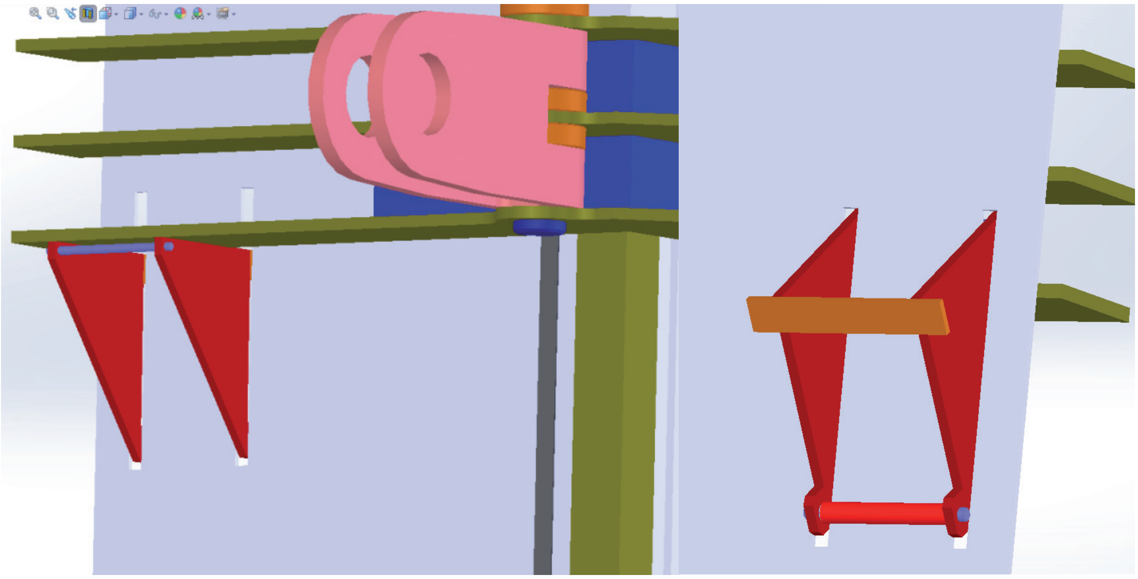

Fig. 10: *Mechanical stop – extended and retracted into tower.*

retracted positions with safety pin.

The finished structure designed according to current valid standards meets all operational requirements as well as requirements for safe operation.

3. Acknowledgments

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