საქართველოს მეცნიერებათა ეროვნული აკადემიის მოამბე, ტ. 2, №4, 2008
BULLETIN OF THE GEORGIAN NATIONAL ACADEMY OF SCIENCES, vol. 2, no. 4, 2008

Mechanics

Transformable Multiple Use of Assault Bridge with 48 Meter Span

Elguja Medzmariashvili

* Academy Member; Major-General; The Institute of Structures, Special Systems and Engineering Maintenance of the Georgian Technical University

ABSTRACT. The existing variants of assaulting bridges, their general schemes, working principles and general tactical and technical parameters are determined.

For the first time in the world an assaulting, deployable bridge is offered with a 48 meter span, which with its dimension and weight, is similar to the existing 24 meter deployable bridge. *© 2008 Bull. Georg. Natl. Acad. Sci.*

Key words: *assaulting bridge, bridgelayer, span, track, truss, girder upper boom, lower boom, strut.*

Military application bridges were constructed several thousand years ago. Their primary function was to allow warriors, arms and equipment to cross barriers – rivers, ravines or other naturally and artificially made obstacles. After military operations these bridges performed the functions of military and civil communications.

Time passed and development of military equipment and bridgebuilding created improved means of erecting bridge structures in the shortest time period [1, 2].

Bridges utilized in the art of war, widely used in different extreme and nominal situations, are divided into three groups [3]:

- Bridges of the rear that are located sufficiently far from the immediate combat operations and their functions are communicational support [4]

- Guiding bridges that are built near the area of combat operations and their main assignment is to ensure transfer of detachments, troops, groups and units in the shortest time period. As a rule guiding bridges are an inventory to be assembled and their installation, for example, in the case of 48 meter length spanning is ensured during 30-120 minutes. Guiding bridges are single or multi-span [5].

In the literature and in practice many analogues of multi-span guiding bridges can be found. This is exemplified by the structure of an assembly inventory bridge composed of unified transformable blocks. The proposed bridge is distinguished for special properties.

Each separate block of the bridge constitutes a universal, arc-shaped system, whose dimension of the roadway and dimension of the supporting part are determined by the profile and depth of the barrier to be overcome through self-regulation.

Over a 35 meter width barrier the time of building of the cited bridge is 45 minutes. At the same time the length of the bridge is not limited.

Notwithstanding a number of special properties, only guiding bridges can be built with the indicated structure [6, 7].

- Assault bridges are predominantly intended immediately for combat operations as well as for use in other extreme situations. Throwing them across barriers should be carried out in the shortest time – 7-10 minutes. During its assembly the personnel do not leave the APCs and the assembly of the bridge is carried out mechanically [8].

The assault bridges [9] that are single-span can be sorted by their basic attribute - according to the collapsible mode of bridge structure that is:

1) The bridge structure without folding - is delivered in full size and is put across the barrier to be crossed (Fig. 1).

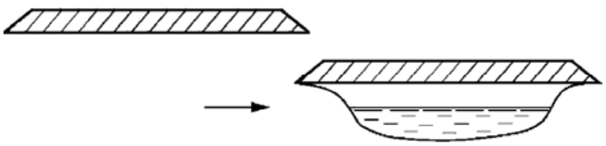

Fig. 1. Bridge without transformation.

The mentioned scheme of assault bridges was widely utilized in earlier solutions. The first modifications of Russian bridgelayer – MTY may be considered as an example of this.

Proceeding from the maximum dimension of their transport package, the length of such bridges could not be more than 12 meters [10].

2) Much more widespread became the bridge designs whose transportation occurs in folded state and their unfolding and throwing across the barrier to be overcome at the site of use. Among them mostly widespread is the so-called “scissor” bridge, double folding design (Fig. 2).

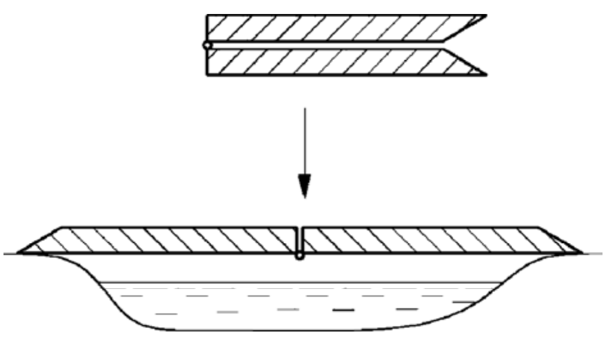

Fig. 2. Hinge-connected two-block bridge.

The indicated design scheme – in conditions of retention of a 12 meter long transport package “allows the bridge span at scissors unfolding to reach 24 meters – became the basis of creating assault bridges in the USA, France and other countries, including the American, K1AV4B type.

The earlier modification of AVLD bridgelayer constitutes a similar analogue.

Creation of military bridges of scissor form design still continues. In 1986 [11] two modifications where adopted in the US armament: a heavy tank bridgelayer and mechanized bridge. whose span can be increased to 30 meters by additional work.

3) The framework of the bridge span is composed of three hinged blocks that in transportation condition have the following appearance (Fig. 3).

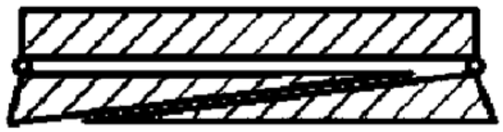

Fig. 3. Three-block bridge.

Such design of the transport package allows to lay a bridge across the barrier to be overcome (Fig. 4).

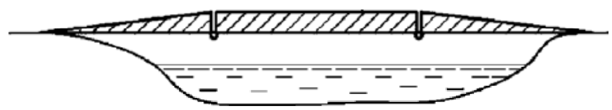

Fig. 4. Three-block bridge in exploition condition.

The Russian deployable single-span bridge – TY-90, placed on the bridgelayer, has such configuration of the folded bridge package.

It should be noted that in TY-90, it is feasible to fold and unfold the bridge from both sides of the barrier to be overcome.

4) There also exists a different scheme of building a bridge under which first an assembly of telescopic arrow is placed across the barrier to be overcome, and then the component blocks of the span are mounted by sliding and joining them (Fig. 5).

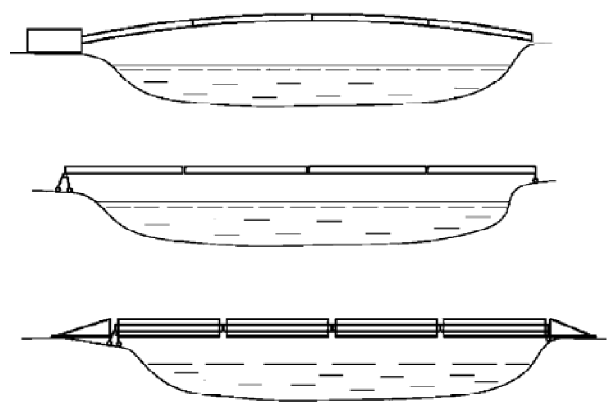

Fig. 5. Mounting telescope and bridge framework built on it.

After the sliding and joining of the span component blocks on the arrow, the latter may be removed or left on the barrier to be overcome.

The German Bridge MLC70 LEGUAN, placed on one vehicle, is mounted by a similar scheme. It is created on the basis of the tank “Leopard” and with its help a 26m barrier can be overcome.

It should be noted that bridging by the erecting sag is becoming widespread in the so-called “guiding” bridges.

Numerous single-span guiding bridges have been built, including the Swedish FAST BRIDGE 48 (FB 48) and German DoFB.

The proposed large-sized single span 48-60 m bridges that are built with the use of supporting structure could not be applied in the so-called "assault" bridges. To begin with, they demand a lot of time to arrange the supporting structure and to install the parts of the span on it, secondly, they are placed on many vehicles.

The given schemes practically do not accord with the design logic of deployable bridges. It is an attempt to cut the classical schemes, install hinges and fold compactly the existing single-span bridges; after that they are unfolded at the site of application and bridged on the obstacle.

This accounts for the main shortcoming by which the overall transporting dimension of folded bridge and dead-weight limit the further increase of the span size. The dimension of the unfolded span for single-span bridges reaches 24 meters, but with certain difficulties and with additional work on the spot, which requires increased time and service, in practice a 32 meter barrier has been overcome with single-span bridges.

In the former case, transport package has a clearance gauge limit of 12 meters which in unfolded state constitutes a 24 meter span bridge.

In the latter case the unfolded bridge of 32 meter span that, as already noted, is implemented with additional work on the spot, which brings its transporting package dimension to 16 meters, highly complicating the maneuvering process of the tank bridgelayer, attended by other unexpected glitches.

So, it may be said that single span bridges that are designed as an assault system:

- Fail to satisfy the demands of increasing the span up to 32-48 meters;
- Or their rapid erection is not feasible;
- At the same time, in some cases, on top of the demands, work is to be done on the other bank too;
- In the case of an increased span the number of mounting facilities and vehicles increases, which is unacceptable for assault systems.

Proceeding from this, our main purpose is:

- To create a single-span deployable bridge design of 48 meter span with the length of its transport package less than 12 m and place it on a single transport-installation facility;
- The mounting and dismantling of the bridge be carried out in the shortest time – maximum in 10 minutes.
- The mounting and dismantling of the bridge structure will be carried out by the personnel without leaving the transport-installation facility;
- The transportation of the bridge and its placement across the barrier to be overcome in addition to a tank bridgelayer, will be feasible from a vehicle and helicopter.

Basic Principles of the Transformation and Design of the New Bridge

According to the mentioned demands, many designs of 48 meter assault span bridges were developed. Transformable structures constitute their basis in which the form-creation logic of deployable systems is demonstrated, allowing to create new, totally different construction designs of deployable bridges [12] (prior. pat. – Georgian pat, № 9950/01, 27.04.2007; prior. pat. – Georgian pat, №10492/01, 29.01.2008).

Analysis of the bridge and bridgelayer structures according to schemes, discussion of the transporting and mounting conditions and of the tactical technical parameters of the bridge span structure determined the selection of the optimal one out of the variants developed.

A deployable combined bridge consists of type I middle beams of roadway and type II extreme and middle beams that are united in two tracks, in blocks of alternating groups with the main shafts placed in longitudinal direction (Fig. 6).

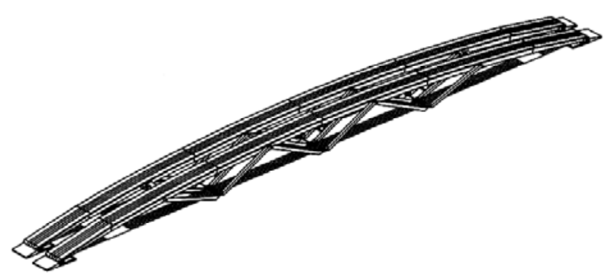

Fig. 6. Deployable bridge with 48 meter span.

Apart from the above mentioned, the tracks at the ends of the deployable combined bridge are formed of type I half-beams and type II extreme and middle half-beams. In alternating groups, they are attached with support shafts that are divided into two parts.

Type I middle beams are fixed by rigid joints with main shafts and type I middle half-beams, but type II extreme and middle beams are attached to the main shafts and type II extreme and middle beams are attached to the support shafts with main cylindrical joints.

On the whole, in the longitudinal direction, adjacent beams I are fixed with cylindrical joints located in the most remote area of the single beams and the extreme half-beams are attached to the top and bottom shafts by tracks.Such scheme allows to fold and unfold the deployable combined bridge and in the unfolded state to use it as a roadway (Fig. 7).

Fig. 7. The bridge transformation process.

The supporting shafts are attached to the gussets that rest on the base-plate with sliding joints linked with them.

Also, on the supporting shaft that is divided into two parts by the tracks, fixing arm, in which flexible flanges are secured, are connected with the cylindrical joints of the anchors.

The deployable bridge has upward and downward braces that on both sides of the tracks are attached by one end to the main shafts by the cylindrical joints of brace.

As to the lower ends of the braces, they are connected by the lower cylindrical joints of the braces to cross-rods where moveable flange joints are also located.

Thus, the execution of the lower flange of the deployable combined bridge with flexible rods does not contradict its collapsibility.

The bridge design whose roadway and braces are aluminum elements, while the lower rod is of steel, weighs the same as the known solutions of American, Russian, German and other bridges, i.e. 17-19 tons, but the span of the Georgian bridge is 48 meters and in other solutions it totals 24 meters.

The fact is of importance that the bridgelayer that is assembled on the basis of "Abrahams", "Leopard", or other heavy tank carries out the assembly by the classical scheme – according to the "falling arrow". The schemes of the transportation of the bridge and its assembly are presented in Fig. 8.

The proposed variant of assembly allows, by application of the jig mounted on the bridge, to lay it on the obstacle to be overcome by the central scheme, which is the same with the scheme used in assembly of the bridge by means of helicopter. (Fig. 9, 10).

In this case the helicopter – M-26TM can be used, whose carrying capacity on the outer jack is 18150 kg., but inside of the fuselage 20000 kg. The "NATO" code of the mentioned helicopter is "Allo". The bridge can be transported and assembled by the American helicopter – CH-53E, whose maximum carrying capacity is 16330 kg.

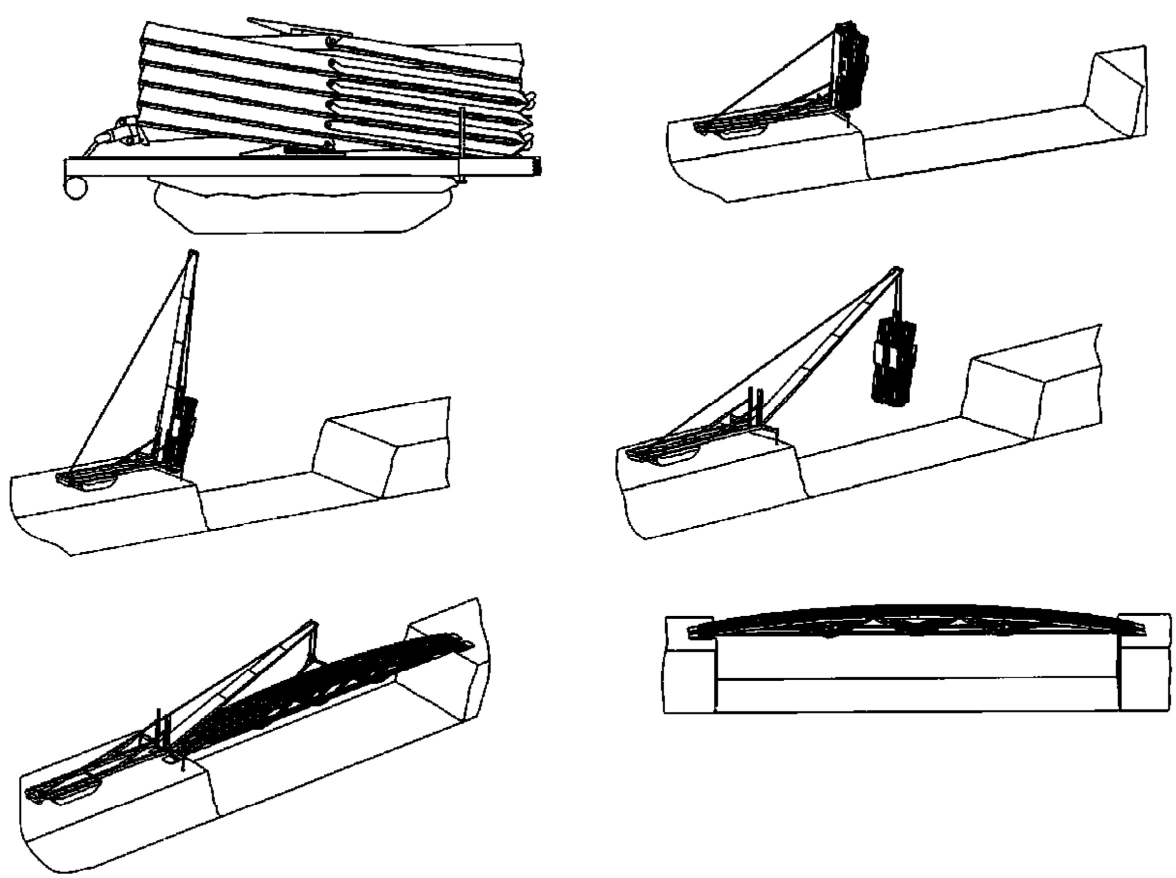

Fig. 8. Stages of the assembly of the 48 meter transformable bridge.

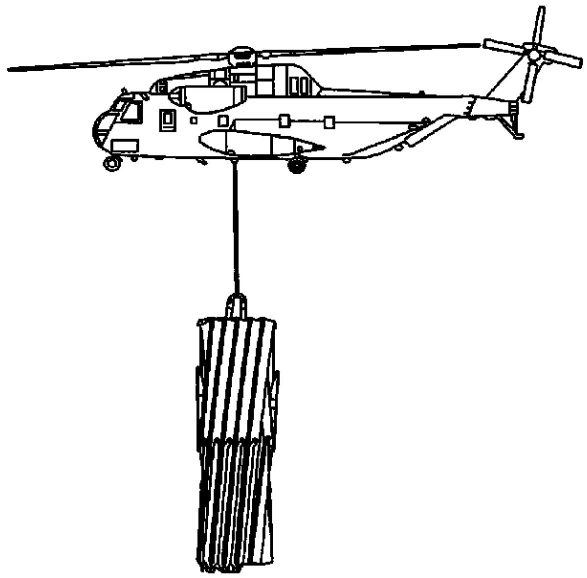

Fig. 9. Transportation of the bridge by helicopter.

The calculation of the bridge design is carried out in three stages.

At stage I an approximate engineering calculation of the elements of the structure and tentative marking of their traverses are carried out [13, 14], this being indispensible for computations.

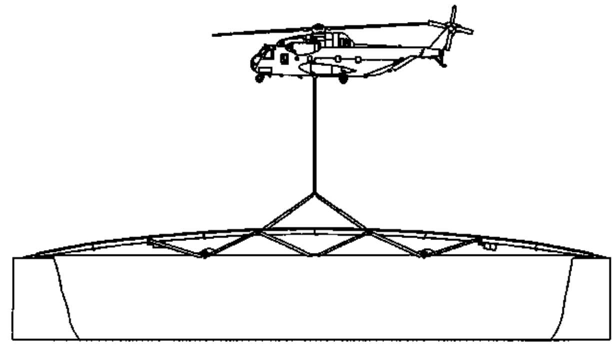

Fig. 10. Assembly of the bridge by helicopter.

Stage II includes computation of the structure – with standard programs – "Nastran", "Ansis", and "Lira-2008". As the results indicate, the computations by the mentioned programs have shown differences of about 2%-5%, which is quite satisfactory. At the same time, the mentioned differences were caused through entering variously improved calculation schemes in different programs. The geometrical parameters, permanent and temporary loadings and their combinations were

Comparison Scheme of Tactical and Technical Parameters

Parameters	FV4205 Great Britain	REMB. U.S.A.	Heavy Tank Bridgelayer. France	AVLB. U.S.A.	HAB. U.S.A.	"Bieber" (F.R.G.)	Georgian Project
Carriage	3	2	3	2	2	2	2
Class of Carrying Capacity	60 t.	70 t.	50 t.	60 t.	70 t.	60 t.	70 t.
Outer Dimensions							
Length	13.7 m.	16 m.	11.4 m.	11.8 m.	16 m.	11.4 m.	11.2 m.
Width	4.16 m.	4 m.	3.8 m.	4 m.	4 m.	4 m.	4.1 m.
Height	3.9 m.	4.3 m.			4 m.		4.3 m.
Total Length of the Bridge Girder		31 m.	22 m.	19 m.	31 m.	22 m.	50 m.
Width of the Obstacle to be overcome	22.9 m.		20 m.	18 m.		20 m.	48 m.
Total Mass	52.5 t.	37.6 t.	40 t.	50 t.	52 t.	45 t.	53 t.
Weight of the Bridge Girder	–	16 t.	8 t.	15 t.	16		17 t.
Time of Bridging	3 min.	5 min.	8 min.	3 min.	5 min.	3-5 min.	7min.
Base tank	"Chieftain"	M1 "Abrahams"	AMX-30	M60A1	M60A1	"Leopard"	1 "Abrahams" "Leopard" T-84
Helicopter	X	X	X	X	X	X	МИ-26ТМ CH-53E

basic during the theoretical research of the structure.

In individual elements of the structure the longitudinal span – N, the torsion torque according to the axes - M, shearing force - Q and displacements with regard to the x, y and z axes were determined.

– Maximum longitudinal force in the upper boom totals $N_{\text{upper boom}}$=386 tons/

– Maximum value of the torsion torque at the lower boom totals M = 120 t.m.

– Stretching force in the stretching $N_{\text{stretching}}$ = 27 tons, and the compressive force - $N_{\text{compressive}}$ = 15 tons.

– Longitudinal force in the flexible lower boom N = 438 tons.

At the same time, the maximum displacement against the X axis of the extreme support joint - $\Delta_x^{\max} = 8$ cm.

But the maximum displacement of the Z axis against the middle lower joint - $\Delta_z^{\max} = 47.5$ cm.

The cross-sections of elements were selected according to the cited force factors and their weights were calculated, accordingly as a result.

– The weight of the upper boom roadway totaled - 10 870 kg. It is manufactured from a high strength aluminum alloy.

– The total weight of the lower boom, made of flexible ropes, is 3 100 kg. It consists of 84 ropes, whose diameter is Ø11 mm. The ropes are of steel and their design strength R = 10. 000 kg/cm^2

– The total weight of brace manufactured from a high strength aluminum alloy is 2 460 kg.

– The metal shafts of Ø100 mm in diameter and with thickness δ= 4 mm and Ø 40 mm in diameter and thickness δ = 10 mm weigh 612 kg.

– The supports manufactured from a high strength aluminum alloy weigh 714 kg.

Thus, the total weight of the bridge amounted to – 17 696 kg.

According to the comparative table of the tactical-technical parameters, in which all large-sized bridgelayers are entered, including the Georgian variant, it is important that the Georgian bridge with transport package of 11.2 meters is easier to transport and is fully maneuverable on roads and in reaching the obstacle; but as to the obstacles to be overcome, i.e. 48 m, it is the main record parameter that is achieved only by construction of Georgian bridges.

As to the width of the bridge, it is selected only according to the designing conditions and neither its increase nor decrease contradict the main principles of bridging. At the same time, other bridging schemes are worked out that comply with conditions of their use in combat operations.

მექანიკა

გასაშლელი მრავალჯერადი გამოყენების საიერიშო ხიდი, მალით – 48 მეტრი

ელგუჯა მეძმარიაშვილი

აკადემიის წევრი, გენერალ-მაიორი, საქართველოს ტექნიკური უნივერსიტეტის ნაგებობების, სპეციალური სისტემებისა და საინჟინრო უზრუნველყოფის ინსტიტუტი

ნაშრომში წარმოდგენილია საიერიშო ხიდების არსებული ვარიანტები და სქემები, მათი ძირითადი პრინციპების – გაშლის სქემების კლასიფიკაციით. ასევე, განხილულია არსებული ხიდების ნაკლოვანებები და მოთხოვნები ახალი, გაზრდილი ტაქტიკურ-ტექნიკური პარამეტრების მქონე ხიდების შესაქმნელად.

ნაშრომში, პირველად მსოფლიოში საიერიშო ხიდების შექმნის პრაქტიკაში, შემოთავაზებულია და განხილულია საიერიშო ხიდი, რომელსაც არსებული 24 მეტრიანი მალის მქონე ხიდებისაგან განსხვავებით

აქვს 48 მეტრის მალი. ამასთან, მისი სატრანსპორტო პაკეტის გაბარიტები და წონა, აგრეთვე მისი მონტაჟის დრო იგივეა, რაც გააჩნიათ 24 მეტრიანი მალის მქონე ხიდებს.

აღსანიშნავია ისიც, რომ ადამიანის უშუალო ჩარევის გარეშე, ხიდის მონტაჟი ხორციელდება 7-10 წუთში და იგი შეიძლება შესრულდეს როგორც ტანკიდან, ასევე ვერტმფრენიდან.

REFERENCES

1. Engineering Operations (2005), FM 5-100 (3-34), USA, 295 p.
2. *ე. მეძმარიაშვილი* (2006), საქართველოს სამხედრო-საინჟინრო დოქტრინის საფუძვლები, თბილისი, ტექნიკური უნივერსიტეტი, 1059 გვ. [*E. Medzmariashvili* (2006), Foundations of Georgia's military-engineering doctrine, Tbilisi, Technical University, 1059 p.].
3. River-crossing Operations (2003), FM 90-13. USA. 207p.
4. *С. А. Ильясевич, С. В. Тарановский, Н. А. Нивин* (1961), Мосты и переправы. Москва, 420 с.
5. Машины инженерного вооружения (1964), Москва, 460 с.
6. *E.Medzmariashvili and others* (2008), New space reflex structures: "Problems of Mechanics". International Scientific Journal. ISSN 1512-0740 N 1(30). 24 p.
7. *E.Medzmariashvili and others* (2008), Structure and kinematic analyses of arch transformed structure: "Problems of Mechanics". International Scientific Journal. ISSN 1512-0740 N 1(30). 53 p.
8. *Н. Сердцев, Н. Евтушенко* (2000), Танковый мостоукладчик AVLB – 70: Зарубежное Военное Образование, № 6.
9. *Е. С. Колибернов, В. И. Корнев, А. А. Соснов* (1989), Справочник офицера инженерных войск. Под редакцией маршала инженерных войск С. Х. Аганова, Москва, 375 с.
10. Машины инженерного вооружения. (1964), Москва.
11. *Н.Л. Волковский* (1997), Энциклопедия Современного Оружия и Боевой Техники, Санкт-Петербург, Том второй.
12. *Э.В. Медзмариашвили* (1995), Трансформируемые системы в космосе и на земле. Германия – Грузия, 447 стр.
13. Металлические конструкции (1998), Справочник проектировщика, Москва,1010 с.
14. Под редакцией *А. А.Уманского* (1972), Справочник проектировщика расчетно-теоретический, т. I, Москва, 599 с.

Received September, 2008