

# Stressedly-deformed state in concrete as in composite material under compressive loads, and rational reinforcement by circumferential steel

## 混凝土受軸壓之應力應變行為及圍束鋼筋之作用

資料來源：俄羅斯工程院



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### ABSTRACT

**This article contains analysis of stressedly-deformed state in concrete under compressive loads, when tensile stresses appear. The method of coil reinforcement considerably decreases these stresses under direct compression.**

The suitability of fillers for heavy-weight and light-weight concretes is being tested by crushing tests in cylinder. In the process, it is generally agreed that filler strength for heavy-weight concretes must be 1.5-2 as much as the grade of the concrete. For light-weight concretes of high grades (B22,5 and higher) filler crushing strength in cylinder must not be over 3 MPa. It is often allowed that the ultimate strength and the modulus of deformation are interdependent, which provides the basis of nondestructive testing methods usage. But the reasons of stress concentration in composite materials are the differences in moduli of matrix deformation values, and inclusion of composite materials.

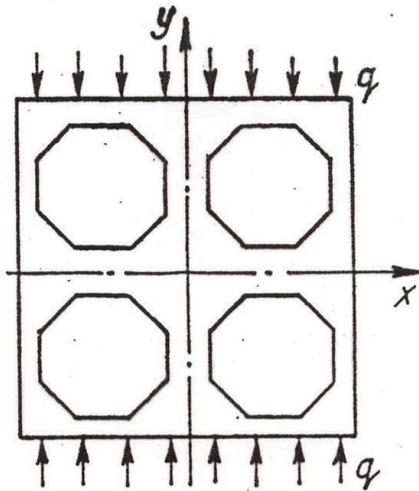


Fig. 1. Calculation model of concrete as of composite material.

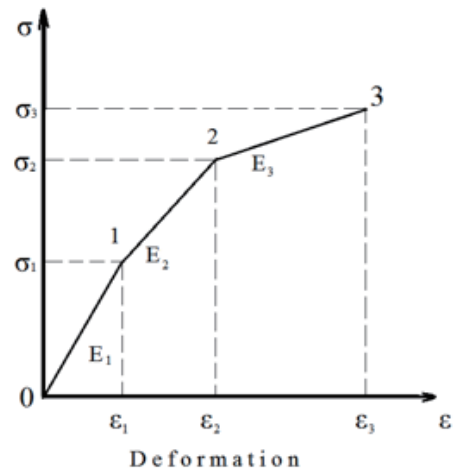


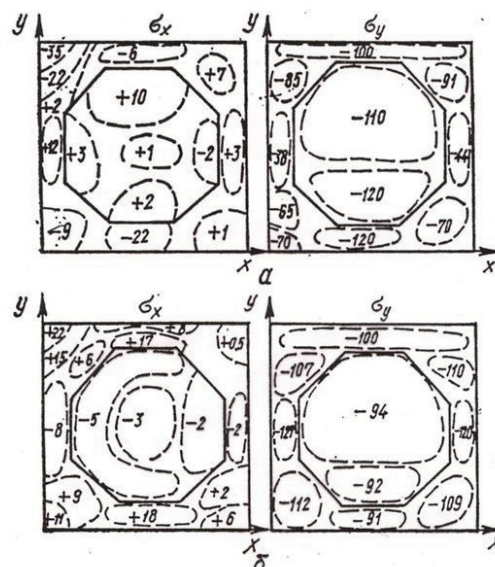
Fig. 2. Type of dependence between tensions and deformations.

Let us consider a model of concrete in which filler is represented as a set of octahedrons evenly distributed in the matrix part of the concrete. The pattern of such composite material is influenced by equidistributed compressive load « $q$ » (fig. 1).

For the stress analysis in the components of distributed load influence we can use finite element method, dividing all the field of the model into triangular elements [1]. The authors of this paper suggest considering a nonlinear dependence between tensions for various components of concretes and for concrete materials. For such purposes during the usage of finite element method, a simplified methodology of calculation by iteration method of nonlinear dependence between tensions  $\sigma$  and deformations  $\epsilon$  was created and is being used. Such nonlinear dependence takes place in real materials (fig. 2).

Nonlinear dependence may be represented as a polygonal chain, e.g., 0-1-2-3. In the 0-1 part the ultimate stress will be  $\sigma_1$ , the ultimate strain will be  $\epsilon_1$ ; in the part 1-2  $\sigma_2$  and  $\epsilon_2$ , respectively.

Iteration method is a method of successive approximations. Originally, in calculations, the elements belonging to the given component were given coefficient of elasticity  $E_1$ . If it comes, after complete calculation, to the result when in one or in a number of elements tensions or deformations exceed limited values of  $\sigma_1$  or  $\epsilon_1$ , this element is given a new value of coefficient of elasticity  $E_2$ , equal approximately  $(0,5-0,6)E_1$ .



a – if filler coefficient of elasticity ratio to mortar component coefficient of elasticity  $E_b/E_m = 3$ ; b – if ratio  $E_b/E_m = 0.7$ ; area borders with equal tensions are shown by hachures, tensile stresses are shown by «+», compressive stresses are shown by «-».

*Fig. 3. Fields of value distribution of horizontal  $\sigma_x$  and vertical  $\sigma_y$  tensions from external load with intensity  $q = 10$  MPa for  $1/4$  of the concrete calculation model.*

The calculation is being checked without increase of the load. If in the issue of the redistribution of tensions or deformations, in new elements, tensions or deformations exceed  $\sigma_1$  or  $\varepsilon_1$  respectively, this element is also given a new value of coefficient of elasticity. The external load is gradually increased, after each calculation the stressedly-deformed state of the model is analyzed. If in the element which is originally given the value of coefficient of elasticity  $E_2$ , tensions of deformation appear exceeding  $\sigma_2$  and  $\varepsilon_2$  respectively, this element is given a new value of the coefficient of elasticity  $E_2$ , which is near-zero, i.e., it is supposed that the destruction of the element occurred, so the element is practically taken out from the work of the model.

The accepted simplified methodology of calculation of the nonlinear dependence between tensions and deformations makes it possible to retrace the change of stressedly-deformed state of the concrete model down to its complete destruction. The flat calculation model of concrete as a composite material with four inclusions is represented on the fig. 3.

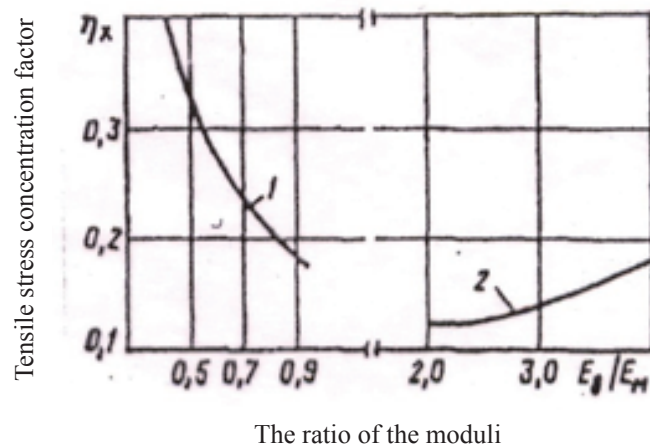
In the performed calculations, the ratio of the coefficients of elasticity of the inclusion  $E_b$  and the matrix  $E_m$  varied within  $E_b/E_m = 0.5 \dots 0.9$  and  $E_b/E_m = 2 \dots 4$ . The ratio of inclusion volumes to the general volume of the concrete varied within 0,35-0,45. The shape of the inclusions was taken round, polyhedral and rectangular with different angle orientations with respect to external load direction.

Of the three structural factors, studied within mentioned limits, the greatest influence on the stressedly-deformed state and the ultimate strength of concretes is exerted by the ratio change of the coefficients of elasticity in the filler and in the mortar component (fig. 3).

Stress concentration zones and the absolute magnitude of the latter considerably depend on the ratio of coefficients of elasticity of inclusion and of matrix. When the coefficients ratio is  $E_b/E_m > 1$ , the type of the tension field is similar to that represented on the fig. 3a. When the ratio is  $E_b/E_m < 1$ , the type of the tension field is similar to that represented on the fig. 3b. Following the change of ratio of these coefficients of elasticity, the tensions are measured only by the absolute magnitude.

The concentration of tensile stresses from the ratio of coefficients of elasticity is of special interest: 1 – at  $E_b/E_m = 0.9 \dots 0.5$ ; 2 – at  $E_b/E_m = 2 \dots 4$ , as the ultimate tensile strength of concretes and their components is by a factor of ten lower than compression resistance.

The analysis of model calculation results for heavy- and light-weight concretes makes it possible to determine the following main regularities of creating a structure with maximal usage of mechanical properties of the components.



- 1 – with  $E_b/E_m = 0.9 \dots 0.5$   
 2 – with  $E_b/E_m = 2 \dots 4$

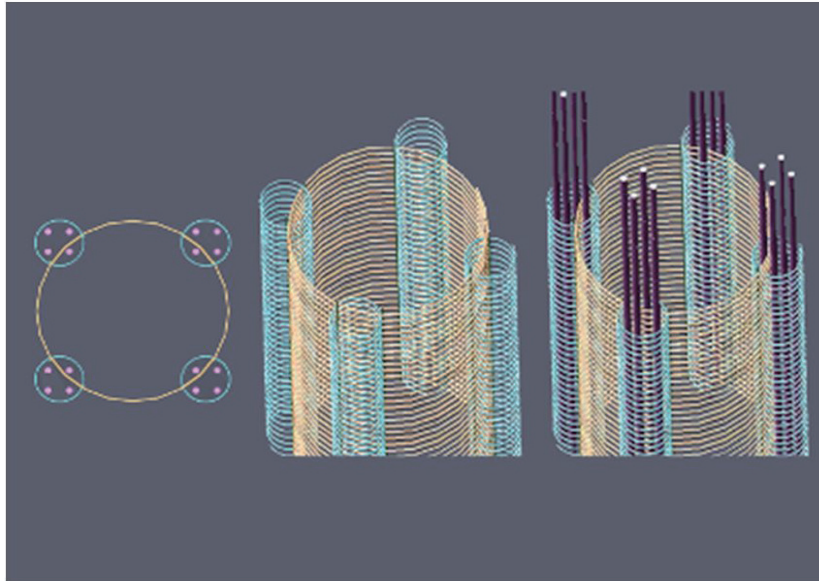
*Fig. 4. Diagrams of dependence of notch sensitivity index  $\eta$  from the ratio of coefficients of elasticity*

For heavy-weight concretes it is most reasonable to use components with ratio of coefficient of elasticity and matrix  $E_b/E_m = 2 \dots 3$ . The higher ratio of coefficients of elasticity significantly increases the concentration of the most dangerous tensile stresses.

The usage of fillers like expanded clay is not reasonable as their coefficient of elasticity is lower than 0.7 of the coefficient of elasticity of the mortar component, because in the process the concentration of tensile stresses increases significantly.

The volume concentration and the shape of the coarse aggregate don't make significant influence on stressedly-deformed state and the ultimate strength of the concrete, so they may be chosen according to economical reasonability.

Concrete is a composite material which consists of components various by their deformation properties, besides this, it has considerable porosity ranging from 2 to 6 per cent. With such characteristics, under the influence of compressive loads in such materials, tensile stresses appear. In this paper it is shown that tensile stresses in the plane perpendicular to the lowering one may reach 40 per cent from the load value. At the same time it is known that in fragile materials (such as concrete), the ultimate tensile stresses total just from 5 to 10 per cent from the compressive stresses.



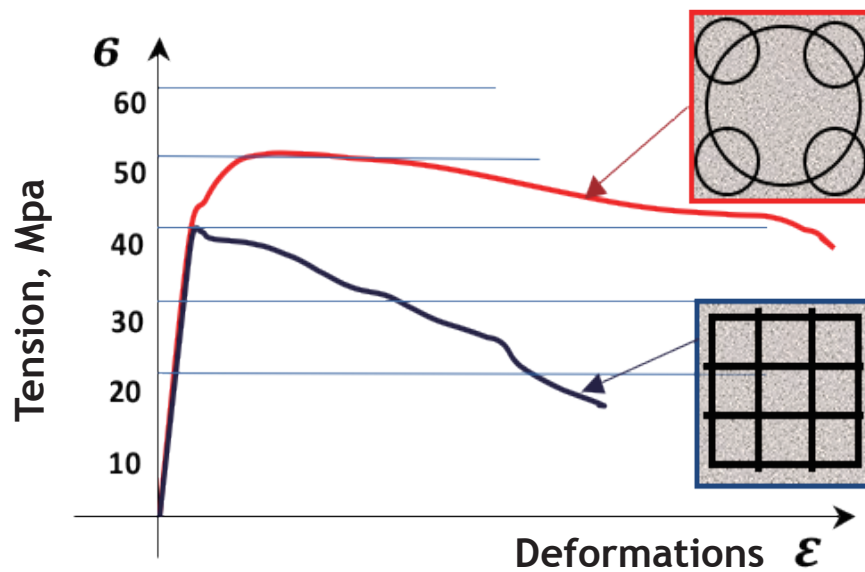
*Fig. 5. Three-dimensional concrete reinforcement by coil reinforcement steel*

So, about 30 per cent of all the amount of concrete in construction is being prestressed. Let us consider a biaxially-reinforced plate 24 meters in length, 5 meters thick. Prestressing of the plate far and wide makes it not just flexible, but provides the increase of concrete density. Nonetheless, prestressing with reinforcement is rather complicated and expensive process.

Another well-known example of construction carrying capacity increase is pour in pipe. In that case, the pipe receives inner tensile stresses in concrete, and tensile load is transmitted to and received by walls of the pipe. The same effect may be obtained during the spiral reinforcement according to the technology by S. Yen-Liang Yin.

In the paper [2] it is shown that concrete can be rather efficiently reinforced with spiral reinforcement. In the process, compressed stress in concrete is provided, and tensile stresses can destroy only the protective part of the construction down to armouring, keeping the construction in the whole in operating condition. On the fig. 5 it is shown a reinforcement of a column in the shape of a coil or a number of coils in the corners of the column. The same coils may exist at rectangular, ellipsoid and other cross-sections of the column.

On the fig. 5 there are some examples of «tension-deformation» for different types of reinforcement.



*Fig. 6. Carrying capacity of column fragments with different types of reinforcement.*

It should be mentioned that there was created simple coil equipment of any diameter, thus showing that a simple idea can be a work of genius. So, one can say that preconditions for development of a whole area in providing of concrete three-dimensional reinforcement are created.

On the fig. 6, dependences of «tension-deformation» for various types of reinforcement are shown. With the usual reinforcement, the column quickly collapses (Diagram 1).

Despite of the fact that the rate of reinforcement is high and two times as much as the version with coil reinforcement, the carrying capacity of columns with coil reinforcement will be considerably higher. Interestingly enough, that on the diagram 2 the column with coil reinforcement keeps its carrying capacity for a long time with further deformation process.

On the fig. 6 it is shown that coil reinforcement doesn't make it possible for concrete to collapse inside the circumferential reinforcement.

The construction of making reinforcement cages, described by S. Yen-Liang Yin in his works, is marked by simplicity and singularity.

### Reference

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2. Samuel Yen-Liang Yin. Novelties in ferroconcrete constructions reinforcement. – M.: Delovaya Slava Rossii, 2008. 58 p.



# Low intensive laser stimulation as the effective method for improvement of disturbed accommodation and prophylaxis of myopia advance

## 以低強度雷射法預防及改善眼睛近視

資料來源：俄羅斯工程院

One of the main factors inducing development of myopia is weakening of the accommodation ability of the eye accompanying myopia advance in children and teenagers and very frequently precedes myopia occurrence.

A method of transscleral laser therapy is directed to improvement of accommodation and normalization of the functional ability of ciliary muscle. The effect of low-energy IR-laser irradiation (the wavelength is 1.3  $\mu\text{m}$ , MACDEL-09) increases metabolic activity ciliary body cells and the eye hemodynamics is improved.

In 1992-1994, clinical tests were performed on 68 children aged 7 – 17, with progressive myopia within the range of 0.5 – 3.0 D. The average increase of accommodation reserve per day of laser therapy equaled 0.3 D. This increase was slowed down between day 7 and 10, giving 0.1 D per day.

**The increase of relative accommodation reserve** in teenagers and elder children was noticeable since day 3 of laser stimulation. In younger children, the increase was slower, and the relative accommodation reserve increased since day 4 - 5.

A significant shift of **the nearest point of clear vision** was observed for children aged 13 - 16 eye approach by 1.27 cm (equivalent to 2.4 D), for schoolchildren aged 10 - 12 the eye approach by 1.16 cm (2.2 D) was observed. Slightly shorter approach of the nearest point of clear vision was observed for schoolchildren aged 7 – 9: 0.94 cm (0.7 D).

In all cases, laser therapy caused average increase of **rheographic coefficient** from 2.07‰ to 3.44‰ which indicated a reliable increase of blood filling of vessels in the ciliary muscle e.g. ciliary muscle perfusion and function are improved.

The indices obtained are preserved during 3 months after the course implemented and decrease 5 - 6 months after the treatment, but remain higher than before it. The repeated course of treatment allows for normalization of these indices.

The method is included to the system of measures for myopia prophylaxis and treatment, applied in Helmholtz Research Institute of Eye Diseases. Since 1993, therapeutic treatment by MACDEL-09 device (2 courses per year) was applied to several thousand patients with myopia. Many therapeutic institutions in Moscow and other Russian cities are equipped with these devices.

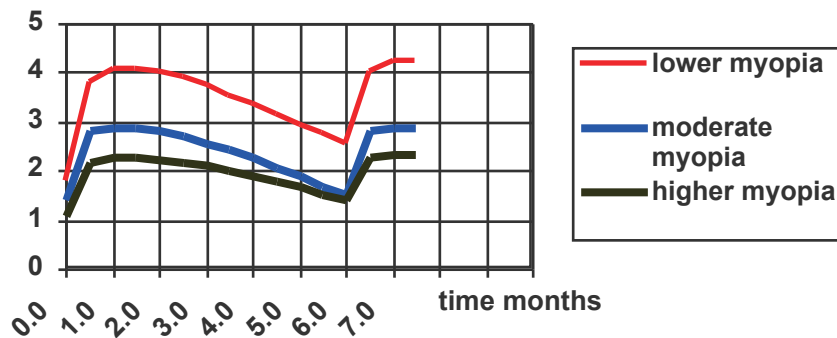
The tactics for transscleral IR laser stimulation of the ciliary body is developed: the treatment course consists of 10 daily sessions and is repeated every 6 months during 3-5 years. The indication for current treatment is slowly progressing (below 0.75 D/year) lower,

moderate and higher myopia in patients 7 – 30 years old. Rapidly progressing myopia (above 0.75 D/year) requires treatment implementation, most often combined with sclera-strengthening procedures.

No signs of irritation of the ciliary body, external eye shells, as well as damaging impacts on retina and visual nerve were observed. The last statement is confirmed by functional (perimetry) and electrophysiological studies carried out in 15 patients, randomly selected from the group of treated patients.

Thus, the method of transscleral laser stimulation using MACDEL-09 device is the effective measure for myopia advance prophylaxis. The method can be used in dispensaries. It is tolerable for patients and easy to implement by the intermediate medical staff and optometrists.

## Dynamics of accommodation reserve variation



## Dynamics of refraction at long-term observation

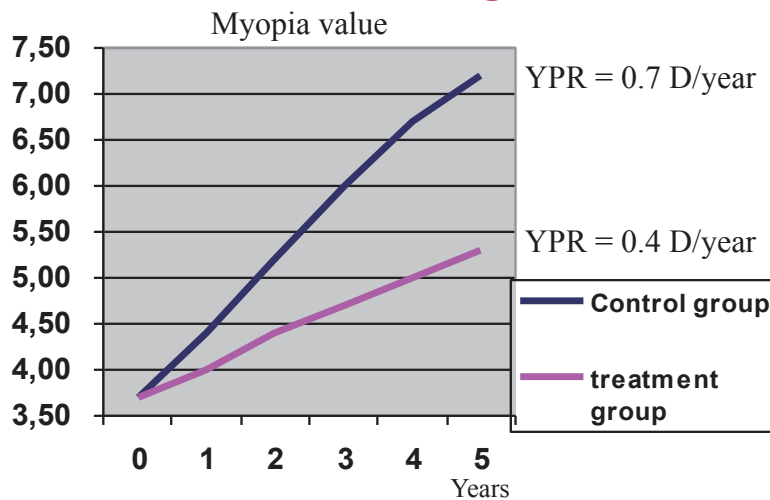


Diagram one clearly shows that at lower myopia e.g. at its timely detection, the advance of it is not only stopped, but the initial indices of vision can be improved. At higher myopia, its advance can be stopped.

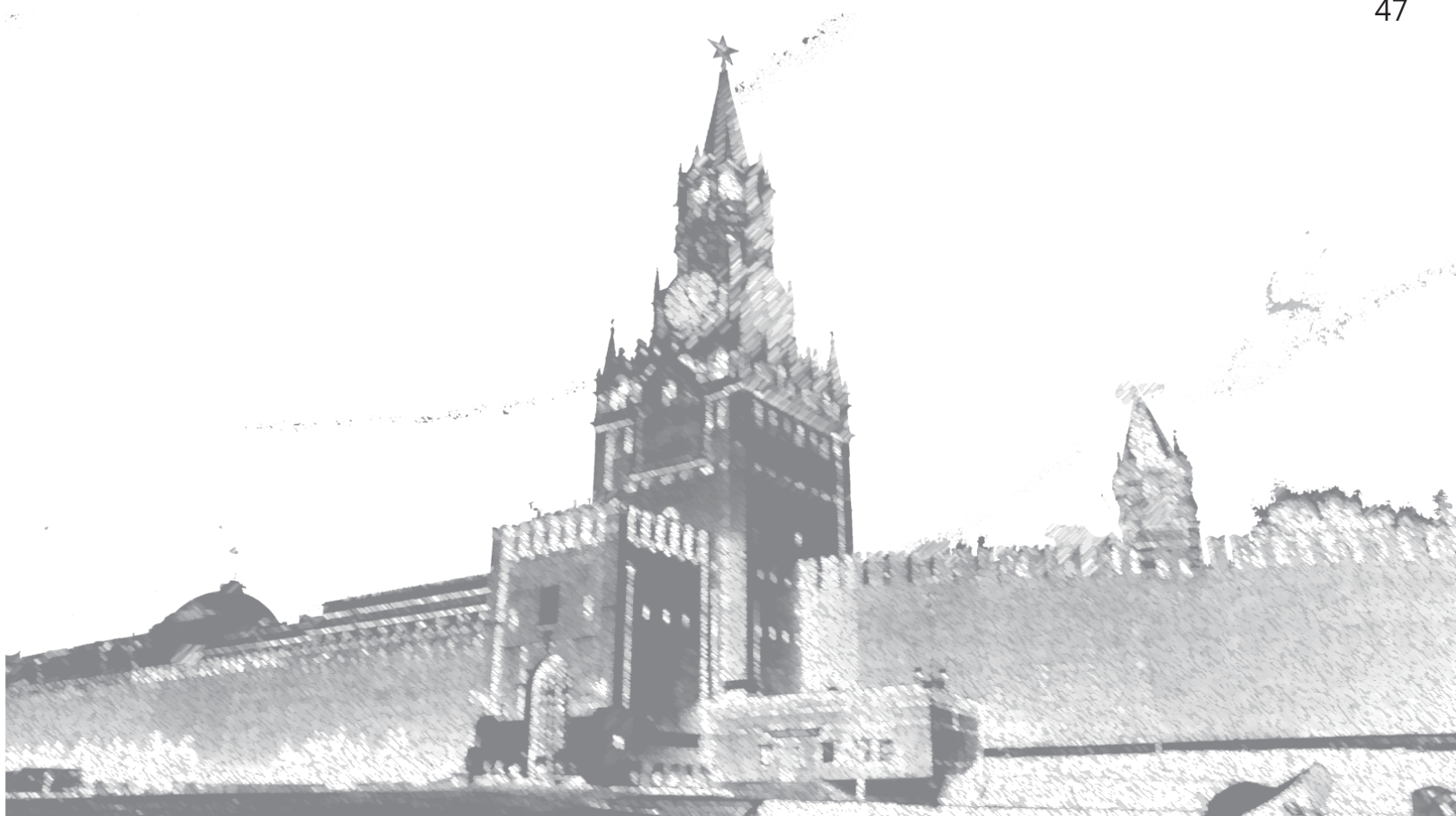
Diagram two presents results of long-term

observation for patients with much higher initial myopia (above 3 D). For treating the control group, totality of the methods for myopia treatment, optimal for the current moment, was used. For the treatment group, MACDEL technology was used. A considerable difference in treatment results allows for

accepting the MACDEL technology the most effective therapeutic method. This will help in saving many problematic patients from disability and arise the question about considerable, by an order of magnitude or higher, decrease of the number of patients with

myopia at the establishment of vision monitoring and prophylaxis service.

Potential users of this technology is about 35 – 45% of the population of every developed country.



## A set of laser ophthalmology devices for therapeutics and prevention of vision disturbances



The medical technology for treatment and prevention of vision disturbances results from the fundamental researches implemented in Helmholtz Moscow Research Institute of Eye Diseases. It comprises techniques for treatment and a set of devices providing for laser effects.

### IR laser device for therapeutics of accommodation-refraction vision disturbances

The device effects on the ciliary muscle, laser radiation does not hit the eye.

The therapy results are preserved during 4 – 6 months.

Treatment and prevention of myopia, amblyopia, nystagmus, heterotrophy, eye fatigue, rehabilitation and preventive maintenance of post-operation complications of ceratorefractive operations.

The application in a complex with MAC-DEL-00.00.08 device and usual ones is recommended at the treatment by eye trainings.

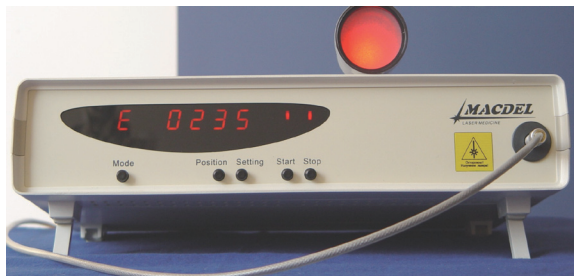
Radiation penetrates through transparent media of the eye and hits retina.

The efficiency of preventive maintenance of children's and adolescent myopia exceeds 90 % that solves the problem of myopia by preventive measures. The treatment comprises 10 – 12 procedures, 3 – 5 minutes long each.

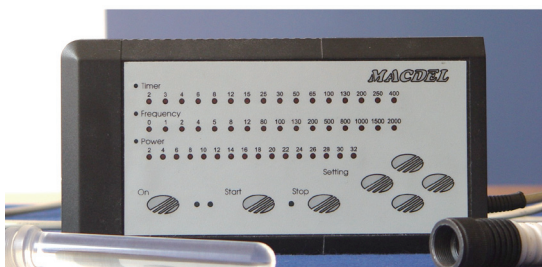
**Indications** are the same as for MCDE-DL-00.00.09 application, but accents e.g. amblyopia, myopia, eye fatigue, posttraumatic rehabilitation, cornea metabolic diseases, lachrymal gland dysfunction, etc.



**MACDEL-00.00.09**



**MACDEL-00.00.08**



**MACDEL-00.00.02**

The treatment consists of 10 - 12 procedures, 5-10 minutes long each. Therapy results are preserved during 4 - 6 months. The presence of optical socket located in front of the screen allows the device application to treatment of lachrymal gland dysfunction and supporting reflex therapy. Higher average power (7 – 8 mW) of the device versus the analogues provides the adequate dose for the patient during reasonable time.

Applied as a component of an ophthalmologic complex, the device is intended for treatment of herpetic eye diseases and their aftereffects, allergic and trophic keratitis, recurrent cornea erosions, ceratoconjunctivitis, ulcerous blepharitis, lachrymal gland dysfunction, cataracts, and glaucomas. The laser effect on cornea is combined with laser puncture and drug therapy.