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REGULARITIES OF ROCK PRESSURE DISTRIBUTION UNDER SAFETY PILLARS AND COAL STRATUM EDGES

Abstract. The development of formation formations leads to the formation of a large number of zones of high rock pressure (HRP) in the thickness of rocks, formed by the influence of the reference pressure of the boundary parts of the massif and the pillar left on the adjacent layers. The presence of HRP zones sharply worsens the condition and preparatory workings of capital in the development of the Suite of layers. The article presents the results of the analysis of the observations in the areas of underground workings of coal mines of the Karaganda coal basin, located under the pillar and the regional parts of the overlying coal seams. The results of the studies showed that in all the workings in which observations were carried out, the height of the work site located under the whole (the regional part) varies wavelike. In the result of the analysis proved the wave nature of the stationary reference pressure and the regularities of its distribution under the pillars and boundary parts of coal seams.

Key words: bearing pressure, coal target, edge part of coal seam, zone of increased rock pressure, formation, preparatory development, harmonic process.

Introduction. It is known that the rock pressure changes gradually in areas adjacent to stratum edge (Webber wave). It's most comprehensively studied in [1] for areas adjacent to breaking face. Another study, [2], notes that the kinetics of front abutment pressure forms in a wave shape. These studies have demonstrated that the abutment pressure has an undular profile with developed periodic sequence of elevated and reduced fornt abutment pressure zones.

Reference [3] studies the undular nature of abutment pressure under safety pillars and stratum edges, reveling the damped sinusoid pressure pattern along the stratum proportional to distance from the source of abutment pressure.

Material and Methods. The analysis of these studies shows that the formation of abutment pressure has a periodic nature (damped sinusoid). The acoustic studies show that the periodic process (whether damped or continuous) can never be the result of interfering, nonlinearity of medium, dispersion or frequency dependence of whatever nature. All these processes and features of medium may cause nonlinear distortions, generate harmonic oscillations, but may never actually generate oscillations, which requires separate oscillatory system [4].

All natural sciences, as acoustics, mechanics, electrodynamics, nuclear physics deal with ocsillations. The physical nature of oscillatory processes varies widely, e.g. the oscillations of a railway bridge and the oscillations in a LC contour are of completely different nature. However even a brief study of these oscillations reveals that they have much in common. Detailed analysts shows that the oscillatory processes we observe follow the major common rules regardless of their nature [5]. This raises the question: to what extent the oscillatory process generated by the abutment pressure corresponds to the common laws of oscillatory theory, acoustics in particular.

As per acoustic data the oscillatory systems of coal stratums are uniform plane parallel lythologic units. Such resonating layers comprising of bounding lithologic units - limestone, sandstone, siltite, agryllite - are the half-wave longitudinal thickness-shear resonators, so that

$$h = \lambda/2 = V_{\phi}/2f_0 ,$$

where h - thickness of resonating layer; λ – medium specific wave length; V_{ϕ} – characteristic frequency of resonator layer; f_0 – phase velocity of compression waves.

The coal, combustible shale or liquid strata are non-resonating layers. Such non-resonating layers being merely a sound wave guide in carbonaceous rock does not distort the spectral composition of the echo of impact force applied to resonator layers.

The geoacoustic measurements use the ability of coal stratum (non-resonating layer) to acoustically decouple resonating layers located to both sides of it (top rock and bedrock). This decoupling ability allows differentiating top rock and bedrock echoes during acoustic investigation, thus making it possible to separately study features of top and bedrock.

Acoustic features of resonating layer determine the following:

- its surface oscillability;
- the amplitudes distribution over the surface of resonating layer;
- spatial distribution of own oscillations.

When applied to abutment pressure propagating under the safety pillars and stratum edges these stipulations are transformed into the following:

1) the resonating layers are presented by strong rock types (limestone, sandstone, slitstone), because the coal layer and other incompetent layers, being porous and fractures, adsorb rock pressure by inelastic deformation thus being unable to resonate.

2) coal layer and other incompetent layers do not add anything to the qualitative representation of distribution of abutment pressure due to their non-resonating nature;

3) the features of resonating layer (sandstone, slitstone) define distribution of oscillation amplitudes and their spatial distribution along the layer;

4) the wavelength of periodic process caused by redistribution of abutment pressure in resonating layer is defined routinely by the equation applicable to any halfwave P-wave resonator:

$$\lambda/2 = h_{c.p.}$$

where $h_{c.p.}$ – thickness of resonating layer, meters.

Results and discussion. Studies confirm these hypotheses. Wherever elevated rock pressure were observed it showed wave nature. The comparison of half wave length of abutment pressure λ/2 with the thickness of top rock $h_{o.к.}$ located over the mine showed direct dependence (figure 1) corresponding to the following equation:

$$\lambda/2 = h_{o.к.}$$

The intensity of manifestation of abutment pressure depends on the following factors: the thickness of rock layer located between the mine and influencing layer h_m and extracted thickness of influencing layer $m_в$. Here the extracted thickness of influencing layer defines the mass of rock supported by coal safety pillar or stratum edge. The more the thickness, the more rock is supported by safety pillar or mine edge and more severely the abutment pressure manifest. This is why it is reasonable to use the comprehensive value of the distance from the excavation to the source of abutment pressure - overworking index $K_н$:

$$K_н = h_м/m_в$$

Using this value and basing on the observations it is possible to find the dependence of the angles formed by the line connecting the border of the crests of the wave with the edge of safety pillar (stratum edge) and the plane of the influencing layer on the distance from the source of the reference pressure is determined (figure 2). This dependence shows the wave nature of abutment pressure. The waves spread from the source of abutment pressure in the depth of rock. However the elevated rock pressure is observed only in areas corresponding to crests of such waves. This is clearly seen on the curve, figure 3.

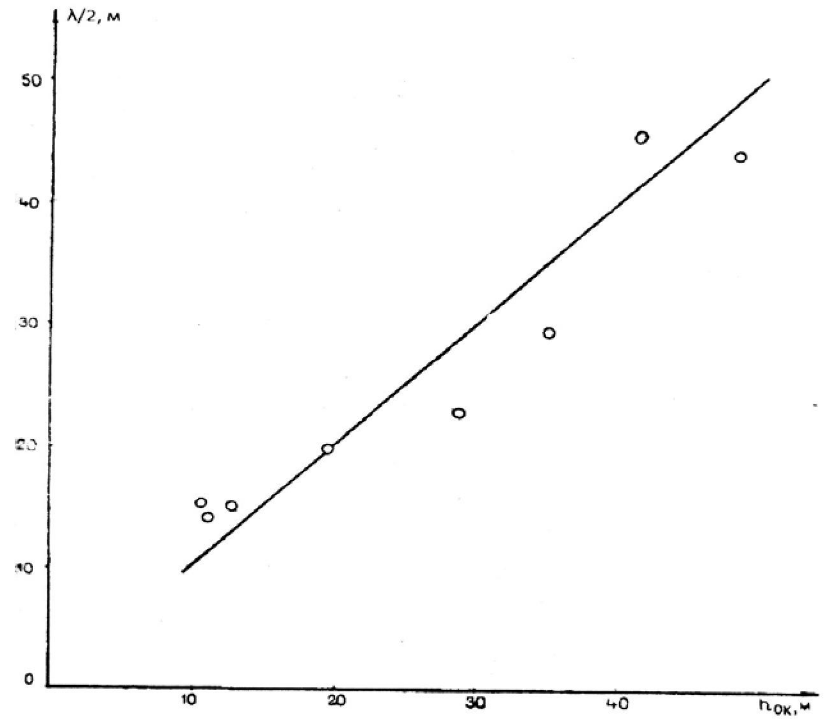

Figure 1 – Wavelength of abutment pressure λ versus toprock thickness $h_{o.к.}$

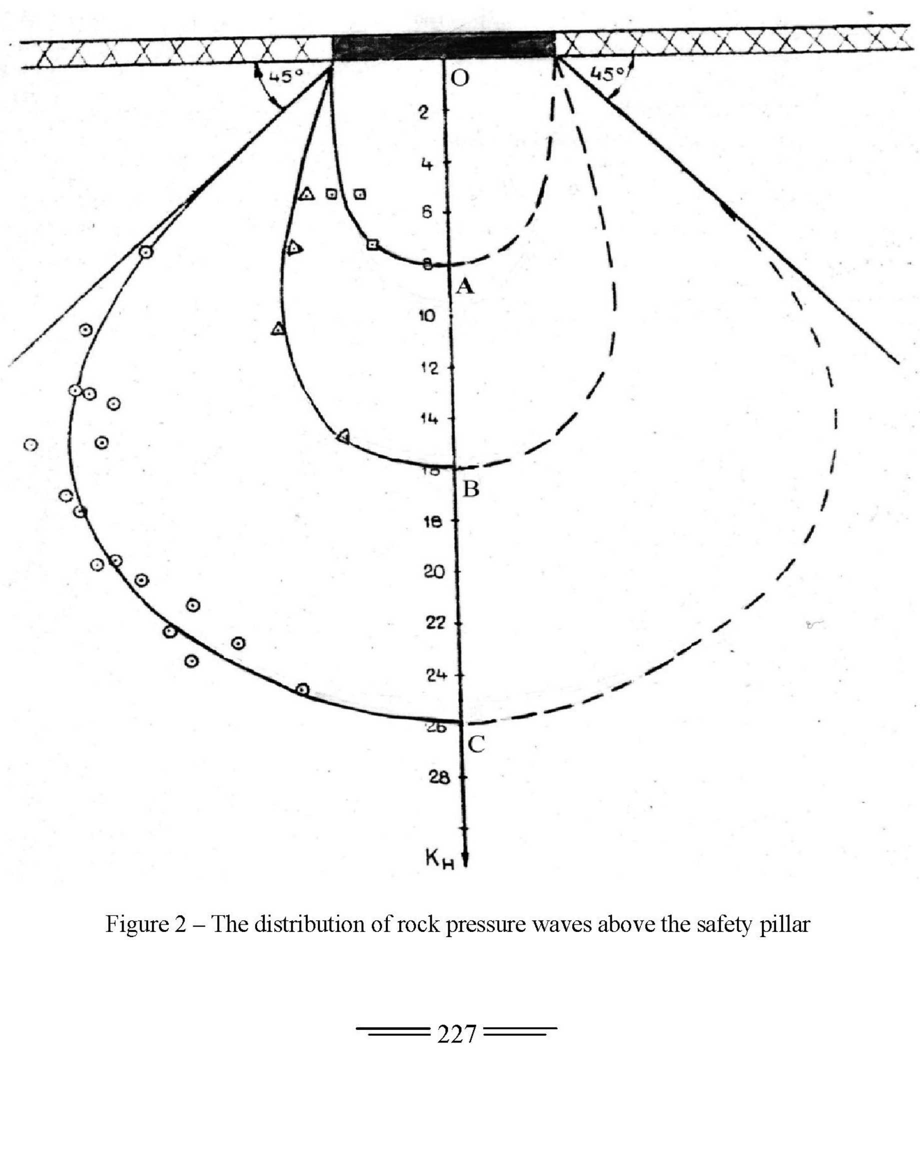

Figure 2 – The distribution of rock pressure waves above the safety pillar

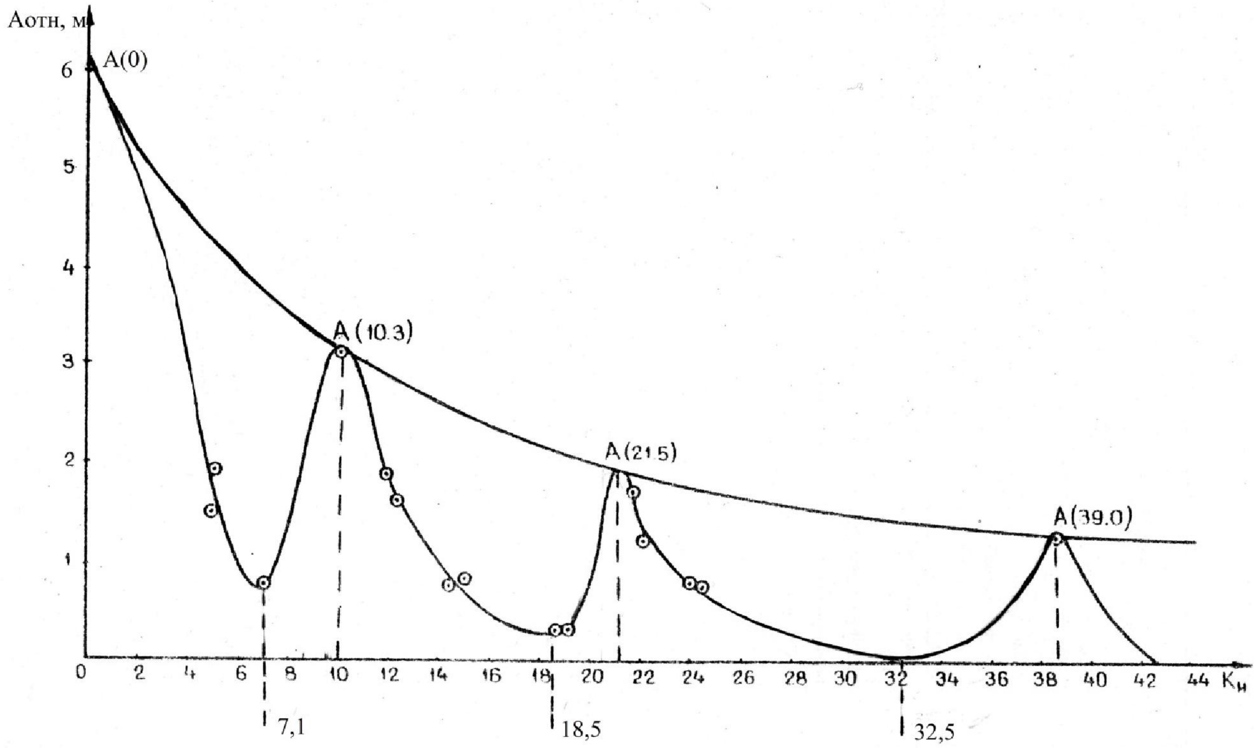

Figure 3 – The change of relative amplitude of a wave A_{om} versus the folding of overworking $K_н$

The comparison of absolute values of mine height oscillation amplitude obtained during studies is of no scientific value as the studies were performed in various conditions (absolute depth, rock composition, life time). Thus, to make comparisons of mines possible, the relative amplitude A_{om} is introduced . The relative amplitude is the ratio of maximum amplitude of the wave A_{max} to the value of decrease of mine height during its life time outside of abutment pressure zone A_0 (i.e. the difference between the original mine height and the height of mine where the wave axis is located). This allows to null out the differences of actual rock conditions and only take into consideration the influence of abutment pressure. The dependence of relative amplitude A_{om} on the distance from the abutment pressure source $K_н$ shows the same crests of pressure waves as on the figure 2, and also shows the areas subject to elevated rock pressure. As seen from the graph the areas subject to elevated rock pressure are interleaved by the areas free from rock pressure [9].

The dependencies represented on figures 2 and 3 allow to find yet another regularity in distribution of abutment pressure. The distances AO, BO and CO (figure 2) are in the following relationship:

AO/BO = 8/16 = 0,5;

BO/CO = 16/25,9 =0,618,

i.e. they agree with the sequence stated in [6] for the zones of higher strength adjacent to mine according to the following equation:

$$X^{n+1} + X - 1 = 0, \quad (1)$$

where X – the ratio of the distance from the edge of previous zone to the edge of the following zone of elevated rock pressure, and n – ordinal number of the zone counting form the base of safety pillar.

The exact values of (1) are given in table 1.

Table 1 – The roots of equation (1)

n	0	1	2	3	4	5	6	7	8
X	0.50	0.6180	0.6823	0.7245	0.7549	0.7781	0.7965	0.8117	0.8243

The values of relative amplitudes of wave crests (figure 3) are also connected by this consequense:

$$A_{(10,3)}/A_{(0)} = 3,1/6,2 = 0,5;$$

$$A_{(21,5)}/A_{(10,3)} = 1,92/3,1 = 0,619;$$

$$A_{(39,0)}/A_{(21,5)} = 1,31/1,92 = 0,682.$$

The distances R to minimums of relative amplitudes of the wave follow the below equation:

$$7.1/18.5 = 0,384$$

$$18,5/32,5 = 0,569$$

i.e. they agree with the sequence stated in [7;8] for the zones of lower strength (fractured zones) adjacent to mine during their zonal disintegration according to the following equation:

$$X^{n+1/2} + X - 1 = 0 \quad (2)$$

The exact values of (2) are given in table 2.

Table 2 – The roots of equation (2)

n	0	1	2	3	4	5	6	7	8
X	0.3820	0.5698	0.6540	0.7055	0.7408	0.7654	0.7894	0.8039	0.8182

This correspondence shows that these zones are the zones free from rock pressure, because they fall onto the lower strength (fractured) zones adjacent to mine during their zonal disintegration

Conclusions. Thus, the revealed wave nature regularities of distribution of rock pressure above (under) safety pillars and stratum edges allow predicting the zones of elevated rock pressure and its manifestation in such zones. The identification of patterns of pressure redistribution above (under) the safety pillars and stratum edges of coal layers will allow to develop reliable methods and recommendations for the identification of elevated rock pressure zones for investigation and producing mines, reduce the length of mines located in the zones influenced by safety pillars and stratum edges of adjacent layers, due to scientifically grounded determination of the configuration and range of influence of elevated rock pressure zones and, as a result, will significantly reduce the cost of managing rock pressure in the investigation and producing mines during excavation of coal strata.

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КӨМІР ПЛАСТАРЫНЫҢ ЖИЕГІНДЕГІ БӨЛІКТЕР МЕН ТІРЕКТЕР АСТЫНДАҒЫ ҚОЛДАУ ҚЫСЫМЫН ТАРАТУ ЗАҢДЫЛЫҒЫ

Аннотация. Пластар свитасын әзірлеу тау жыныстарының қалыңдықтарында үлкен мөлшерде тау-кен қысымының жоғарлауы ТКҚЖ шекарасының түзілуіне алып келеді, ол дегеніміз көрші пластардан қалған массив пен тірек жиектеріндегі қысым әсерінен пайда болған. ТКҚЖ тау-кен қысымының жоғарлау шекарасы пластар свитасын әзірлеу барысында капиталды және дайындалған өңдеулер жағдайын шұғыл түрде нашарлатады. Бұл мақалада жоғарғы жатқан көмір пластарының жиектері мен тірек астындағы Қарағанды көмір бассейні көмір шахтасының жер асты өңдеулері аймағында жүргізілген талдау нәтижелері келтірілді. Жүргізілген зерттеулер нәтижелері көрсеткендей, яғни тіреу астында орналасқан барлық қаралған өңдеулер аймақтарының ұзындығы толқынға ұқсас өзгеріп отырады. Жүргізілген талдау нәтижесінде стационарлы қысымның толқынды өзгеру сипаттамасы дәлелденді және оның көмір пластарының жиектері мен тіреулер астарында таралу заңдылығы анықталды.

Түйін сөздер: қолдау қысымы, көмір тіреулері, көмір пластарының жиек бөліктері, тау-кен қысымының жоғарғы шекарасы, пластар свитасы, дайындалған өңдеулер, гармоникалық үрдіс.

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ЗАКОНОМЕРНОСТИ РАСПРОСТРАНЕНИЯ ОПОРНОГО ДАВЛЕНИЯ ПОД ЦЕЛИКАМИ И КРАЕВЫМИ ЧАСТЯМИ УГОЛЬНЫХ ПЛАСТОВ

Аннотация. Разработка свит пластов приводит к образованию в толще пород большого количества зон повышенного горного давления (ПГД), образованных влиянием опорного давления краевых частей массива и целиков, оставленных на соседних пластах. Наличие зон ПГД резко ухудшает состояние подготовительных и капитальных выработок при разработке свит пластов. В статье приводятся результаты анализа проведенных наблюдений на участках подземных выработок угольных шахт Карагандинского угольного бассейна, находящихся под целиками и краевыми частями вышележащих угольных пластов. Результаты проведенных исследований показали, что во всех выработках, в которых проводились наблюдения, высота участка выработки, расположенного под целиком (краевой частью) изменяется волнообразно. В результате проведенного анализа доказан волновой характер стационарного опорного давления и выявлены закономерности его распространения под целиками и краевыми частями угольных пластов.

Ключевые слова: опорное давление, целик угля, краевая часть угольного пласта, зона повышенного горного давления, свита пластов, подготовительная выработка, гармонический процесс.

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