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DIFFICULTIES WITH TRANSPORTATION OF LONG AND HEAVY SUPPLIES IN COAL MINES

NEKI PROBLEMI DOPREME DUGAČKIH I TEŠKIH REPROMATERIJALA U RUDNICIMA UGLJA

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Abstract: *Timely transport of supplies to the workings is a highly significant task. The supplies that are transported are often large and heavy, which greatly complicates this process. This paper considers some aspects of heavy and long load hauling by means of monorail transporters.*

Key words: *long and heavy supplies, transportation, coal mines*

Apstrakt: *Blagovremeno snabdevanje radilišta u rudnicima uglja repromaterijalom je veoma važan zadatak. Pri tome se javljaju i potrebe za dugačkim i teškim komadnim materijalom čija je doprema dosta složena. U ovom radu se razmatraju neki aspekti dopreme dugačkih i teških repromaterijala jednošinskim visećim sredstvima.*

ključne reči: *dugački i teški repromaterijal, doprema, rudnici uglja*

1 INTRODUCTION

The transportation of supplies in coalmine conditions is a highly complex assignment. Presently, continuous conveyance has significantly hindered the use of rail track haulage. This raises some difficulties in the transportation of supplies to the workings since belt conveyors are not very convenient for the transportation of heavy and long loads.

In underground coalmines as the depth of the mine increases the difficulties with the transportation of supplies raise. The narrow cross-section of underground drivages is a particular impediment, as well as the small radius of curvatures, geo-mechanical properties of surrounding rock, dimensions of transported load, parallel production processes etc.

1 UVOD

Doprema repromaterijala u rudnicima uglja predstavlja jedan veoma složen problem. Potiskivanjem šinskog transporta i njegovom zamenom kontinualnim transporterima, otvoren je problem transporta potrebnih materijala do radilišta. Transporteri sa trakom nisu pogodni za dopremu repromaterijala, posebno teških i dugačkih komada.

U podzemnim rudnicima uglja, sa povećanjem dubine, povećava se i problem transporta repromaterijala. Posebna ograničenja se javljaju usled suženih profila podzemnih prostorija, malih radijusa krivine, geomehaničkih svojstava stena kroz koje se izrađuju prostorije, gabarita tereta koji se prevozi, istovremenih procesa proizvodnje u jami itd.

The frequency of transportation depends on the size of the mine, plants installed, mining district or other elements. However, regardless of the size and production rate, long and heavy loads are always transported in the mine. In highly mechanized mines this problem deserves even more attention.

With a view to a more rational use and maintenance of drivages (along with other advantages) the supplies are usually transported by means of overhead monorail transporters. However, problems arise when extra-large and heavy loads are transported. The aim of this paper is to highlight the problems that arise in coalmines during the transportation of long and heavy supplies and to suggest some methods that should be applied to overcome such difficulties

2 THE SUPPLY OF SUPPLIES REQUIRED IN COALMINES

To define properly the transportation method and to select the most convenient means of transportation it is necessary to determine the amount and the type of supplies that are required in the workings. This amount is usually determined for a specific period, that is, for a shift or for a working day in order to secure an undisturbed supply of material. The most adequate way is to determine the average quantity of supplies, based on standards set for each process in the mine and on the quantity of spare parts and devices stated in the design.

For wood and timber supplies, the quantity required for one-shift operation can be determined by applying the following expression:

$$Q_d = q_d \cdot Q_{sm} \cdot (1 + k_g) + q_d' \cdot L, \quad m^3, \quad (1)$$

Where:
q_d – standard for timber and other wood material per ton of coal for applied mining method,
Q_{sm} – one shift production of coal,
K_g – backup coefficient, which considers the losses that occur due to mine wood use,
q_d' – required amount of timber and lagging material for m^3 of drivages
L – drivage length achieved during one shift.

A considerable amount of metal supplies is used in each coalmine. For this type of load the amount per shift is also based on relevant standards and experience gained in similar mines with similar equipment. Approximate amounts of metal

Učestalost dopreme repromaterijala do radilišta zavisi od veličine rudnika, pogona, revira i drugih jedinica. Međutim, bez obzira na obim proizvodnje, svaki rudnik ima potrebe za prevozom dugačkih i teških tereta za potrebe eksploatacije. Za rudnike uglja sa većim stepenom mehanizacije ove potrebe su veće.

Za dopremu repromaterijala u rudnicima uglja, usled racionalnijeg korišćenja i održavanja podzemnih prostorija (uz druge prednosti), uglavnom se primenjuje jednošinski viseći prevoz repromaterijala. Pri tome se javljaju i određeni problemi, posebno pri prevozu negabaritnih i teških tereta. Cilj ovog rada je da ukaže na neke probleme dopreme dugačkih i teških repromaterijala u rudnicima uglja i da naznači pravce njihovih rešavanja.

2 POTREBNE KOLIČINE REPROMATERIJALA ZA RUDNIKE UGLJA

Da bi se pravilno definisao transport repromaterijala u rudnicima uglja i izvršio izbor odgovarajućih transportnih sredstava, neophodno je utvrditi potrebne količine pojedinih vrsta repromaterijala. Potrebne količine se određuju za neki period, najčešće radnu smenu ili radni dan, kako bi se mogla planirati nesmetana doprema. Za to je potrebno naći prosečne količine repromaterijala, pomoću utvrđenih normativa za svaku operaciju u rudniku i projektovanih količina delova opreme i uređaja.

Za drveni repromaterijal, koji je potreban za rad u jednoj smeni, potrebne količine se mogu odrediti preko sledećeg izraza:

$$Q_d = q_d \cdot Q_{sm} \cdot (1 + k_g) + q_d' \cdot L, \quad m^3, \quad (1)$$

gde su:
q_d – normativ drvene građe i ostalog drvenog repromaterijala po toni uglja za primenjenu metodu otkopavanja,
Q_{sm} – smenska proizvodnja uglja,
K_g – koeficijent rezerve koji uzima u obzir gubitke jamske građe pri upotrebi,
q_d – potrebna količina drvene građe i materijala za zalaganje pri izradi m^3 podzemnih prostorija,
L – dužina prostorije koja se izradi u toku smene.

U svakom rudniku uglja se koriste značajne količine metalnog repromaterijala. I kod ove vrste tereta smenske količine se određuju uz pomoć normativa, ali i iskustva na sličnim rudnicima i sa sličnom opremom. Približne količine ovog materijala

supplies are determined by applying the following expression:

$$Q_g = q_1 \cdot L_1 + Q_{sm} \cdot (q_2 + q_3 + ...q_i), \text{ t.} \quad (2)$$

The symbols given in the previous expression denote:

q_1 – the quantity of metal supports per m^3 of drivages under construction,

L_1 – length of drivage constructed and protected with metal support during one shift,

q_2 – standard determining the consumption of metal elements per each extracted ton,

q_3 – standard determining the consumption of metal spare parts and devices per each ton of extracted coal,

q_4, q_5...q_i – other standards determining the consumption of metal supplies per each ton of extracted coal.

The transportation of extra-long and extra-large material causes major difficulties in every coalmine. These difficulties cannot be avoided even with overhead monorail transporters.

To provide a secure transportation of heavy spare parts for machines and devices to the workings by overhead monorail it is necessary to calculate carefully all the necessary elements. In the first place, each element of the route (rails, chains, junctions), but also all the supports and the roof properties of drivages through which the transport is carrying out. The weight of one hydraulic face support section may be over 10 tons. Other machines or their parts (driving sections, cutter-loaders, plough-type machines etc.) are also very heavy.

The main obstacle for undisturbed transportation of long objects supplied to the workings, (such as rails, ventilation pipes, long mine wood and timber) is the small radius of drivage curvatures both in horizontal and vertical planes. Such loads should be previously prepared to secure safe transportation, that is, they are tightly packed into packages or stacked into special containers (Figure 1).

The supplies are frequently transported to the workings using combined methods, which include one or more transfer points. For this reason it is necessary to adjust the preparation of long size and heavy loads to all the types of transportation used.

se određuju preko sledećeg obrasca:

$$Q_g = q_1 \cdot L_1 + Q_{sm} \cdot (q_2 + q_3 + ...q_i), \text{ t.} \quad (2)$$

U prethodnom izrazu simboli označavaju:

q_1 – količina metalne podgrade po m^3 prostorije koja je u izradi,

L_1 – dužina prostorije koja se izradi u jednoj smeni i osigura metalnom podgradom,

q_2 – normativ potrošnje metalnih elemenata po otkopanoj toni,

q_3 – normativ potrošnje metalnih delova i uređaja po toni otkopanog uglja,

q_4, q_5...q_i – ostali normativi potrošnje metalnih repromaterijala po otkopanoj toni uglja.

Doprema komadnog repromaterijala velike dužine i mase predstavlja problem u svakom rudniku uglja. To nije moguće izbeći ni kod primene jednošinskih visećih sredstava.

Teški delovi mašina i uređaja koji se dopremaju u rudnik visećim transportnim sredstvima zahtevaju pažljiv proračun elemenata trase (šina, lanaca, spojeva), ali i podgrade, pa i same krovine prostorija kroz koje se vrši prevoz. Masa jedne sekcije hidraulične otkopne podgrade može biti veća od 10 tona, pojedine mašine ili njihovi delovi (pogonske stanice, kombajni i sl.) takođe imaju veliku masu.

Za dugačke repromaterijale (šine, ventilacione cevi, dugačka jamska građa) najveća smetnja su mali radijusi krivine podzemnih prostorija u horizontalnoj i vertikalnoj ravni. Ovi tereti se primenjuju za transport tako što se čvrsto povezuju u pakete ili se slažu u specijalne kasete (slika 1).

Doprema repromaterijala se često vrši kombinovanim putem, uz jednu ili više pretovarnih stanica. Zbog toga je neophodno da priprema dugačkih i teških repromaterijala bude prilagođena svim vrstama transportnih sredstava koja se koriste za njihov prevoz.

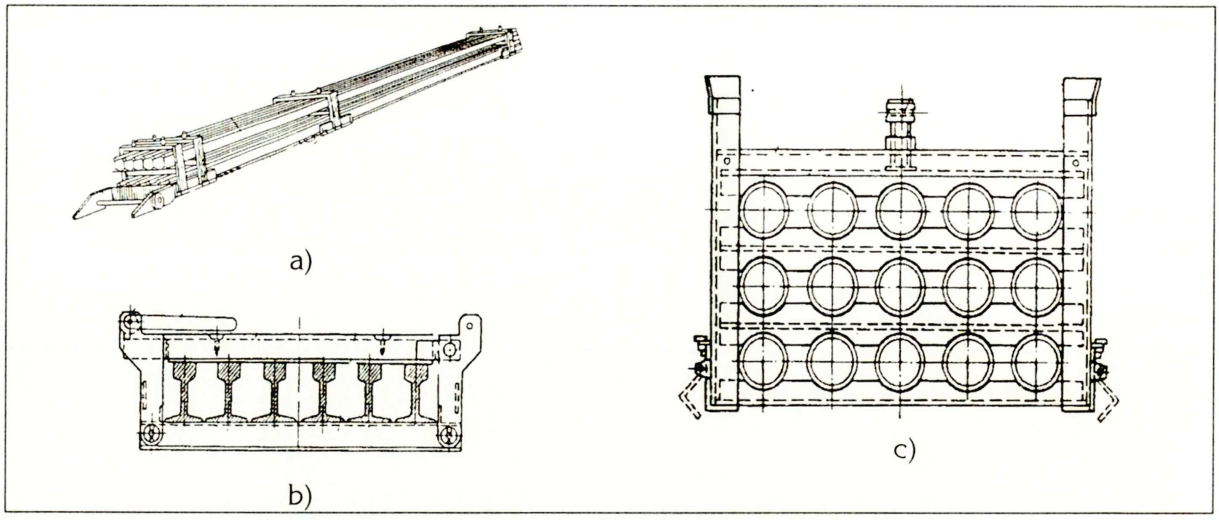

Figure 1 Long size supplies prepared for transport:
a - rail packages, b – rail containers, c – pipe containers
slika 1 Priprema dugačkih repromaterijala za transport:
a - paketi šina, b – kasete za šine, c – kasete za cevi

3 THE CONDITIONS OF HEAVY AND LONG LOADS TRANSPORTATION BY OVERHEAD MONORAIL

To transport safely the heavy parts of machines, devices, support and other items by monorail it is necessary to dimension correctly the load bearing elements. Heavy loads are transported by locomotives, which consist of several elements that are hung on carrying mine cars and adjusted to the length and shape of the load. The mine cars are suspended on driving devices by way of which the load is transferred to rail carriers.

The mine car moves with the load on carriers that are suspended on the roof. Considering that the rail carriers are composed of l-long sections, these sections must be coupled so that the junction moment is equal to zero. In this way each carrier may be regarded as a simple beam.

Critical moments occur when heavy load reaches the center of the carrier suspended on a two-wheel mine car. This situation is even more critical if the route slopes.

In this case maximum bending moment may be calculated in the following way:

$$M_{max} = \frac{P}{2 \cdot l}(1 - \frac{l_3}{2})^2 \text{ , N·m,} \qquad (3)$$

Where:
P – loading of the carrier as the consequence of burden motion,
l_3 – distance between wheels that move on the carrier

3 USLOVI PREVOZA TEŠKIH I DUGAČKIH ELEMENATA JEDNOŠINSKIM VISEĆIM SREDSTVIMA

Teški delovi mašina, uređaja, podgrade i drugih elemenata, koji se prevoze jednošinskim visećim sredstvima, zahtevaju pravilno dimenzionisanje nosećih elemenata. Teški tereti se prenose uz pomoć vučnog voza koji se sastoji iz više elemenata koji su obešeni o noseća kolica i prilagođeni su težini, dužini i obliku tereta. Noseća kolica se oslanjaju na vodeće uređaje preko kojih se opterećenja prenose na šinske nosače.

Pri kretanju tereta noseća kolica se pomeraju po nosaču koji je obešen o krov prostorije. Pošto su šinski nosači sastavljeni od segmenata dužine l, oni se spajaju međusobno tako da su momenti na spojevima jednaki nuli. To omogućava da se svaki nosač može posmatrati kao prosta greda.

Kritični slučaj se javlja kada se teški komadni teret nađe na sredini nosača obešen na kolica sa dva točkića za kretanje. Pri tome je nepovoljniji slučaj ako je trasa pod nagibom.

Maksimalni moment savijanja u ovom slučaju se može izraziti na sledeći način:

$$M_{max} = \frac{P}{2 \cdot l}(1 - \frac{l_3}{2})^2 \text{ , N·m,} \qquad (3)$$

gde su:
P – opterećenje nosača usled pokretnog tereta,
l_3 – rastojanje između točkića za kretanje po nosaču.

To transport heavy loads it is necessary to determine the maximum loading of rail carriers. If the section modulus of a rail carrier W and its flexural bending σ_f, are known, the maximum loading of rail carrier may be determined by way of the following expression:

$$P_{max} = \frac{2 \cdot l \cdot W \cdot \sigma_f}{(1 - \frac{l_3}{2})^2}, \text{ N.} \qquad (4)$$

To determine the flexural bending it is necessary to take into account previously set safety coefficient.

Za dopremu teških tereta neophodno je utvrditi maksimalno opterećenje kojim se može opteretiti šinski nosač. Ako se poznaju otporni momenat šinskog nosača W i njegova dozvoljena čvrstoća na savijanje σ_f, maksimalno opterećenje šinskog nosača se može odrediti preko sledećeg izraza:

$$P_{max} = \frac{2 \cdot l \cdot W \cdot \sigma_f}{(1 - \frac{l_3}{2})^2}, \text{ N.} \qquad (4)$$

Prilikom utvrđivanja dozvoljene čvrstoće na savijanje potrebno je uzeti u obzir i propisani koeficijent sigurnosti.

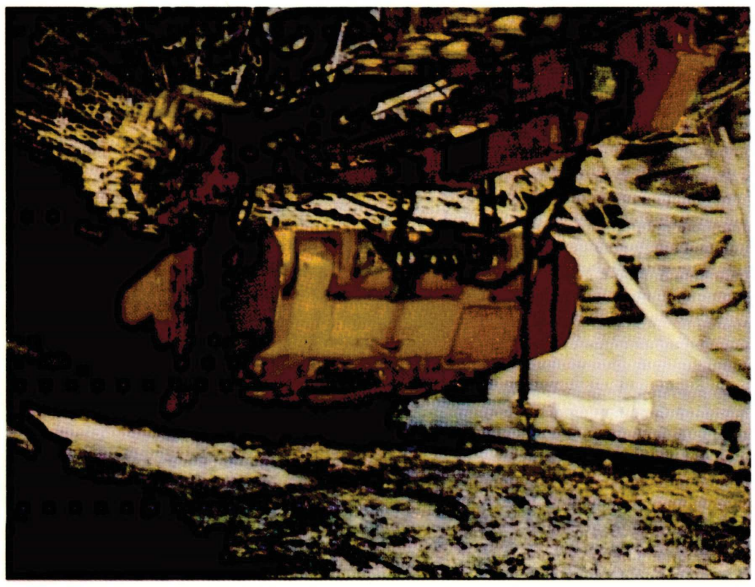

Figure 2 Suspension of hydraulic support section for monorail transport
slika 2 Vešanje sekcije hidraulične podgrade pri prevozu jednom šinom

The carriers are suspended to the roof with chains at junction spots or at certain sections of the carrier also with one or two chains. The chains for suspension may be placed in the axis, or perpendicular to the carrier axis.

Overall loading of the carrier and the burden is transferred via the chain to the support or the drivage roof. For two-chain carrier suspension, perpendicular to the carrier axis, loading is distributed to both chains where tensile strengths appear.

However, when the haulage road enters into a curve at a constant velocity, centrifugal forces appear causing uneven loading. Since chains do not bear pressure, the function of one chain is lost, while the remaining chain bears the entire load.

One of the ways to solve this problem is to control load momentum. Controlling the load momentum

Vešanje nosača o krov prostorije se vrši lancima na njihovom spoju, ili na delu nosača, i ono se obavlja pomoću jednog ili dva lanca. Vešanje sa dva lanca može biti sa postavljanjem lanaca u osi, ili upravno na osu nosača.

Ukupno opterećenje usled težine nosača i tereta se prenosi preko lanaca na podgradu ili krov podzemne prostorije. Kod vešanja nosača sa dva lanca, postavljena upravno na osu nosača, sva opterećenja se raspoređuju na oba lanca, gde se javljaju zatezne sile.

Međutim, pri prolasku trase kroz krivinu konstantnom brzinom, usled dejstva centrifugalne sile javlja se neravnomerno opterećenje. Kako lanac ne trpi pritisak, dolazi do gubljenja funkcije jednog lanca, dok drugi prima celo opterećenje.

Jedan od načina rešavanja ovog problema je regulisanje brzine kretanja tereta. Ograničenje

both chains will stay in function, which may be calculated in the following way:

$$V_{doz} = \sqrt{g \cdot R \cdot tg\alpha_1}\ , \text{m/s}, \qquad (5)$$

Where:
R - radius of curvature
α_1 - angle between one chain in relation to the vertical axis

When heavy loads are transported it is very important to provide even loading of chains to prevent chain rupture due to overloading.

The curves are very frequent in coalmine haulage roads. This problem becomes serious when long loads are to be transported. Figure 3 presents the chart to determine necessary elements of long load motion in horizontal curves.

brzine kretanja, pri kojoj oba lanca imaju svoju funkciju, može se izračunati na sledeći način:

$$V_{doz} = \sqrt{g \cdot R \cdot tg\alpha_1}\ , \text{m/s}, \qquad (5)$$

gde su:
R – radijus krivine,
α_1 – ugao koji zaklapa jedan lanac u odnosu na vertikalnu osu.

Ravnomerno opterećenje lanaca je veoma važno pri prevozu teških tereta, jer u slučaju velikog opterećenja jednog lanca može doći do prekida lanca.

U rudnicima uglja veći deo trase se nalazi u krivini. Ovaj problem je naročito aktuelan pri prevozu dugačkih tereta. Na slici 3 je data šema za utvrđivanje neophodnih elemenata kretanja dugačkih repromaterijala sa horizontalnom krivinom.

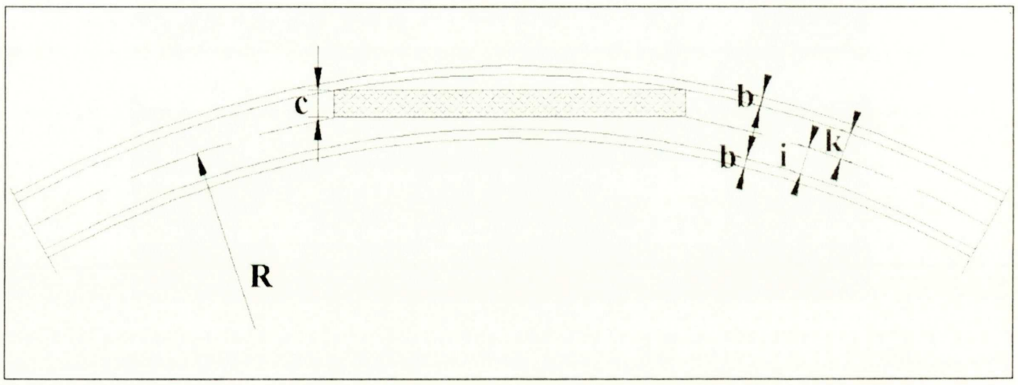

Figure 3 Chart to calculate long load motion in curves
slika 3 Šema za proračun kretanja dugačkih predmeta u krivini

Acceptable length of lump supplies can be determined applying the following expression:

$$l_{max} = 2\sqrt{(2b + c - i - k)(2R + c - i + k)}\ , \text{m} \qquad (6)$$

Where:
R – radius of rail axis curvature,
b – acceptable distance between the load and drivage flanks
c – width of the package with long supplies,
i, k – distance between the carrier axis and drivage flanks.

The design of drivages should comply with the requirements of long and heavy load transportation. In some coalmines the difficulties in transportation of extra-large supplies through available drivages actually qualify the mining

Dozvoljena dužina komadnih repromaterijala se može odrediti preko sledećeg obrasca:

$$l_{max} = 2\sqrt{(2b + c - i - k)(2R + c - i + k)}\ , \text{m} \qquad (6)$$

gde su:
R – radijus krivine ose šine,
b – dozvoljeno rastojanje od tereta do boka prostorije,
c – širina paketa dugačkih repromaterijala,
i, k – rastojanja ose nosača od bokova prostorije.

Prilikom projektovanja podzemnih prostorija, neophodno je voditi računa o potrebi transporta dugačkih i teških elemenata kroz njih. U nekim rudnicima uglja se ograničava primena neke metode otkopavanja, jer postoje ozbiljne teškoće dopreme negabaritnih sekcija kroz postojeće prostorije. Pojedini proizvođači opreme za dopremu

methods that are to be applied. Some manufacturers of equipment for the transportation of supplies even fabricate special-purpose vehicles to transport to the workings the heavy elements of hydraulic mechanized supports primarily taking into account the narrow cross-sections of drivages.

4 CONCLUSION

To enable a timely and functional provision of supplies in coalmines it is necessary to set up an adequate transportation system. This issue becomes particularly significant in coalmines where excavated material is usually transported by means of belt conveyors. The implementation of overhead monorail transporters generally solves the majority of problems, but still the haulage of long and heavy supplies remains unsolved. Therefore, to provide undisturbed transportation of such supplies it is necessary to specify, severally for each mine, the exact quantity of supplies, their characteristics and precise dimensions. In this way it will be possible to determine the transportation parameters and eliminate possible restrictions that occur as a result of drivage inadequacy for such type of transportation.

repromaterijala izrađuju specijalna transportna sredstva za prevoz teških elemenata hidrauličke mehanizovane podgrade do otkopa, vodeći, pre svega, računa o suženim profilima podzemnih prostorija.

4 ZAKLJUČAK

Za funkcionalno i blagovremeno snabdevanje rudnika uglja repromaterijalom potrebno je da postoji odgovarajući sistem dopreme. U rudnicima uglja, gde se transport iskopine često vrši trakastim transporterima, ovo pitanje dobija na značaju. Primenom jednošinskih visećih sredstava rešava se dosta problema, ali ostaje prisutno pitanje dopreme teških i dugačkih repromaterijala. Zbog toga je za svaki rudnik neophodno da se sagledaju potrebe za količinama repromaterijala, utvrde njegove karakteristike i definišu dimenzije. To je veoma značajno kako bi se mogli utvrditi parametri dopreme i otklonila eventualna ograničenja koja nastaju usled nepodesnosti rudničkih prostorija za transport ove vrste tereta.

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