

## Détente par saignée de voies profondes : une méthode efficace pour la lutte contre les coups de terrains

Marwan Al Heib, Pascal Bigarre, Jean-Pierre Josien, Yves Guise

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DETENTE PAR SAIGNEE DE VOIES PROFONDES: UNE METHODE EFFICACE POUR LA  
LUTTE CONTRE LES COUPS DE TERRAINS

A SIMPLE METHOD FOR THE ALLEVIATION OF DYNAMIC PHENOMENA IN MINE  
STRUCTURES

AL HEIB M.<sup>1\*</sup>, BIGARRE P.<sup>\*</sup>, JOSIEN J. P.<sup>2\*\*</sup>, GUISE Y.<sup>3\*\*\*</sup>

RESUME

Dans cet article, nous avons cherché à apprécier l'efficacité de cette méthode par la modélisation numérique. Nous avons utilisé le code UDEC basé sur l'approche des éléments distincts. Cette modélisation valide la méthode et met en évidence son efficacité confirmé par les observations et mesures *in situ*. Elle permet également de comprendre le rôle positive du procédé employé. Les résultats sont très encourageants. Nous avons mis en évidence que l'efficacité de la saignée est d'autant plus importante que les contraintes initiales horizontales sont très fortes.

ABSTRACT

Dynamic floor heavage in deep coal mines may be alleviated using extensive floor slotting before mining operations start. Clearly identified as efficient from *in situ* observations, this method has been tested on numerical simulations of the fractured rock mass. Stress/strain relief in the floor has been qualified and compared with measurements.

Results show that floor slotting is an attractive method for Rockbursting alleviation as well as safe and economical to work out.

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\* INERIS - Ecole des Mines de Nancy - France

\*\* INERIS 60550 Verneuil en Halatte - France

\*\*\* HBCM - U.E. Provence - France

## 1. INTRODUCTION

The management of the Provence Operations Unit of the Houillères du Bassin du Centre et du Midi (Charbonnages de France Group) has drawn up a geological engineering scheme to control dynamic phenomena. This programme introduces a coherent approach tailored to the development of workings in the mine. It is based essentially on methods of relieving stresses around roadways. In principle, the different methods involve eliminating original and induced stress concentrations and modifying the brittle character of the rock mass. If this objective is not achieved, the slot would make it possible to initiate the phenomenon at an appropriate time.

Stress relief holes have been known and used for a very long time. A new method was recently introduced which involves simply making a slot in roadway floors.

In this article, we shall begin by describing the principle of the method and the resources necessary for its application. We shall then give a comparison between a zone to which this method has been applied and one to which it has not.

A numerical simulation using the distinct element method has been carried out to determine the role of the slot and the mechanisms this type of stress relief involves.

## 2. PRINCIPLE OF THE METHOD

A slot is made parallel to the centre line of the roadway. This allows controlled operation with regard dynamic phenomena in the wall and dissipation of the stored energy. Figure 1 shows the roadways in which slots were made. The slot can be produced by a machine fitted with a disk cutter (Fig. 2). The slots currently used by HBCM are 90 cm deep and 15 cm wide. For satisfactory operation, the slot must be produced before the seam is worked. Subsequently the slot is monitored over time to assess its effectiveness.

Figure 3 shows how the width of the slot changes as a function of distance from the cutting face. After the first pass, the measured width is only 7 to 8 cm on the average instead of 15, indicating a closure of the order of 8 cm, virtually half the initial width. It may also be noted that slip between strata is fostered because the

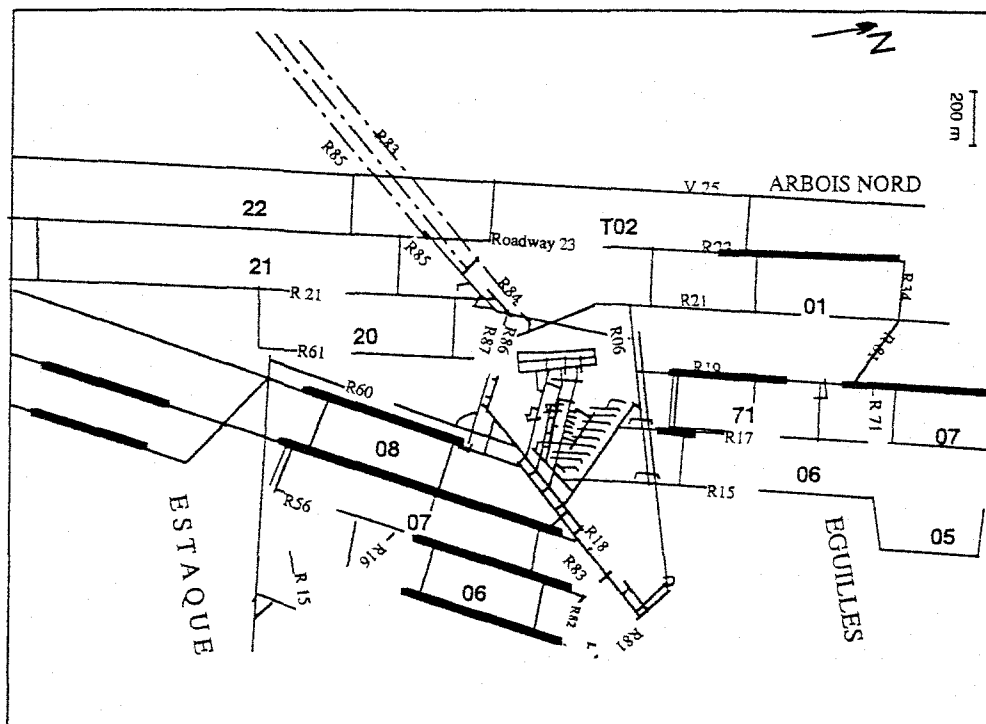


Fig. 1 : Location of slots

measurements and the follow-up observations have often shown a stepped shape. Since 1992 all roadways have been treated with this method.

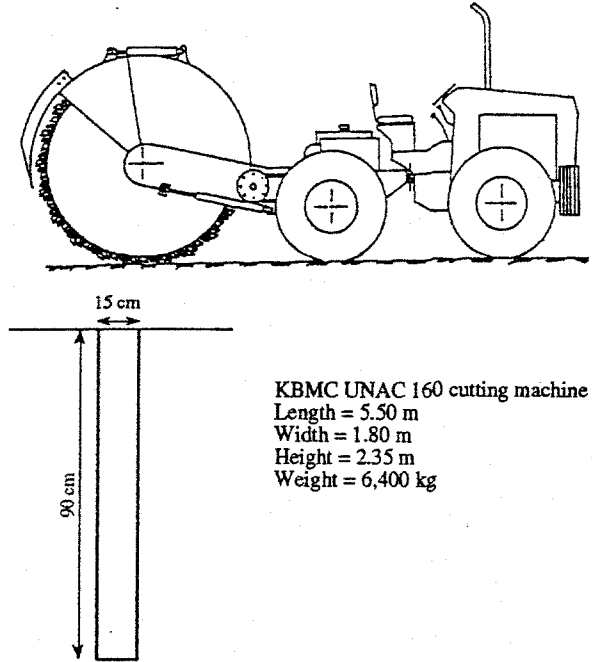


Fig. 2 : UNAC cutting machine

### 3. COMPARISON OF TREATED AND UNTREATED ZONES

A number of faces distributed through all districts were systematically monitored. Table 1 shows that no floor heave was recorded in the treated zones. In the main roadway, no suspicious event was recorded in the treated zones but two suspicious events were recorded in the non-treated zones. Comparison is more difficult in the auxiliary roadways.

### 4. NUMERICAL SIMULATION

The aim of numerical simulation is mainly to understand the stress relief mechanism introduced by the slot in the roadway wall. It is also possible to evaluate the efficiency of the slot in eliminating any danger of wall bowing. The question arises as to whether cutting the slot in the wall of the roadway does not also modify the behaviour and stresses in the roadway facing.

Many parameters influence behaviour, and numerical modelling will also make it possible to determine the influence of each.

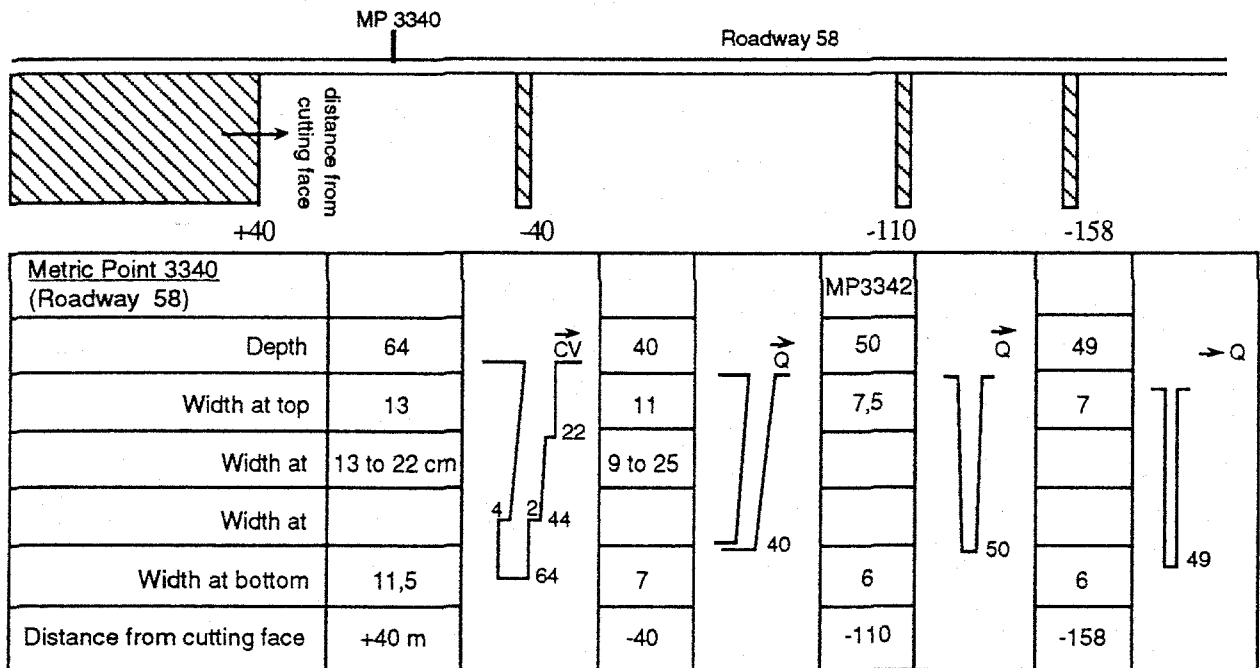


Fig. 3 : Slot changes as a function of distance from the cutting face 17 measured at metric points 3340 and 3342

	T M P		T M A	
	Slotted zone	Non-slotted zone	Slotted zone	Non-slotted zone
ESTAQUE 06		////	06/01/92 08/01/92	////
ESTAQUE T17		////	28/06/92 06/08/92 04/09/92	CT 243 15/04/92
ESTAQUE T07		////	06/01/92	////
EGUILLES T06	////	CT 242 18/11/91 06/12/91	////	11/01/91 14/01/91
EGUILLES T07		////	////	
EGUILLES T71		////	////	06/11/92 at cutting 19/01/93

Légende : CT 242 = ground heave n° 242  
18/11/91 = suspicious event on 18/11/91

Table 1 : Effectiveness of the slot

The UDEC code (ITASCA, 1994) was used. The choice of numerical method (distinct elements) was determined by the substantial stratification for the operation of the slot.

#### 4.1 Description of a model

##### \* Geometry

The roadways excavated in Provence are virtually rectangular in section, 6 m wide and 3 m high. The workings involve alternate seams of coal and beds of limestone.

##### \* Geological characteristics

The strata in the Provence mine mainly consist of very hard rocks ( $R_c > 100$  MPa).

INERIS carried out laboratory tests to characterise the coal and the strata in the roof and walls (TRITSCH, 1993 and GHOREYCHI, 1982). A reducing coefficient of 0.5 was adopted

so as to take fracturing and the real characteristics of the rock into account (BIENAWSKI, 1989). The rocky strata behave in an elastic-plastic manner. The Mohr-Coulomb plasticity criterion was chosen. However the stratification joints were not characterised owing to the difficulties of sampling and testing the joints. The joints were therefore modelled on the basis of theoretical and practical considerations and a number of observations.

##### \* Loading

The initial stresses have been measured over a long period. The results showed that the Provence mine was characterised by major horizontal stresses between 1 and 3 times the vertical stress.

Two loadings were used, one with the vertical stress and a horizontal stress twice as high, the other with the same vertical stress but a horizontal stress of 0.5 times the vertical stress.

The phases of calculation were as follows:

- the roadway excavation phase;
- the slot production phase;
- the advance of the cutting face.

#### 4.2 Results and interpretation

By analysing the parameters it is possible to quantify and analyse the behaviour of the roadway. These parameters are the deformation, the movements of joints and the new stress distribution.

The displacements induced by the production of the slot are found to be in the roadway wall. The displacement caused is equal to a third of the displacement induced by the gallery (Fig. 4).

Changes in the slot depend on the initial horizontal stresses. It can be seen (Fig. 5) that the slot begins to function as soon as it is cut with mobilisation of the joints. The slot is deformed by a greater amount for the simulation of a cutting face.<sup>1(\*)</sup>

The final closure state is of the same order of magnitude as that obtained by the in situ measurements after the cutting pass. The joints in the roadway wall undergo slippage induced by shear stresses. Joint shearing also occurs in the roof supports, which agrees with the observed process of roof damage.

Comparison of the two simulations with and without slots show the value of the slot. The extension of the slip zones due to shear is much greater when no slot is present (Figs. 6 and 7).

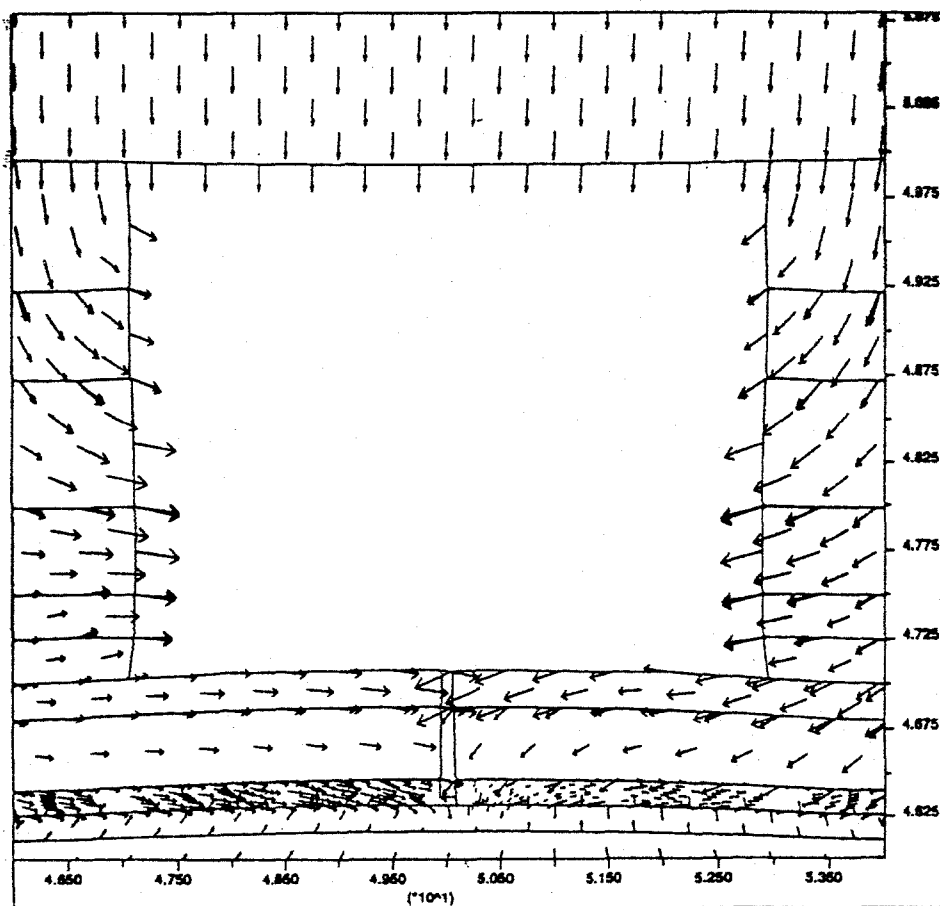


Fig. 4 : Displacements induced only by production of the slot

The high horizontal stresses are localised at the bottom and middle of the wall (60 MPa). Following cutting of the slot, these stresses fall significantly (40 MPa). The stress relief

introduced is of the order of 30%. This relief is not limited only to the wall. The facings are also stress relieved over a considerable distance (Figs. 8 and 9).

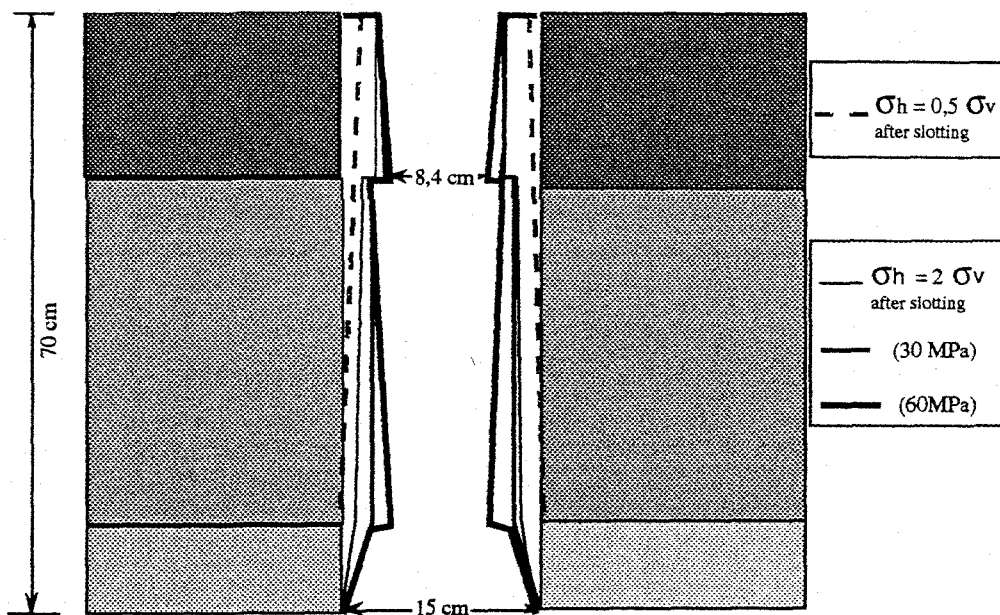


Fig. 5 : Slot section as a function of distance from cutting face

## 5. CONCLUSION

In this article we have analysed the behaviour of the rock mass in the vicinity of roadways treated by slots. Comparison of in situ observations in the treated zones with those made in untreated zones demonstrated the efficiency of this method and led to its being incorporated in the geological scheme for controlling dynamic phenomena.

The numerical modelling approach was used to analyse and quantify the role played by the slot. The results show that the slot makes an effective contribution to stress relieving the wall in the case of high initial horizontal stresses and to stress relieving the roadway facing.

The deformations and displacements obtained by the calculation are comparable with the in situ measurements.

## 6. REFERENCES

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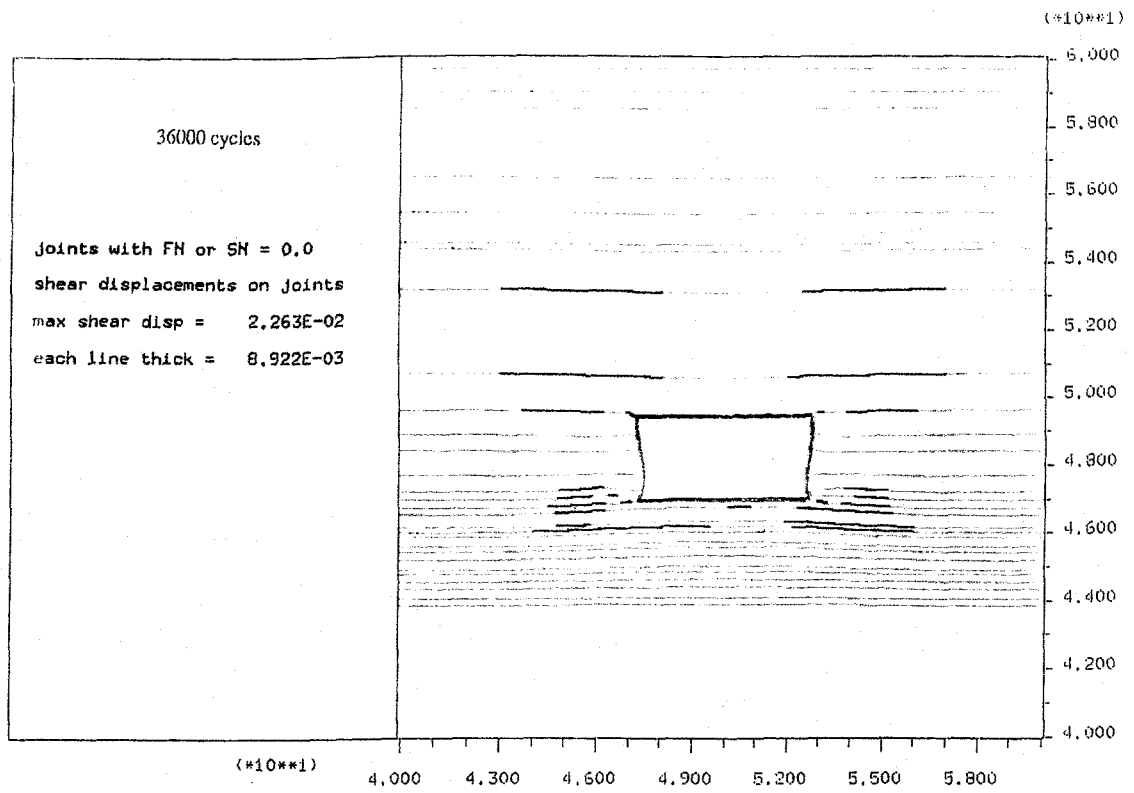


Fig. 6 : Shear displacements of joints after slotting with a vertical loading of 30 MPa

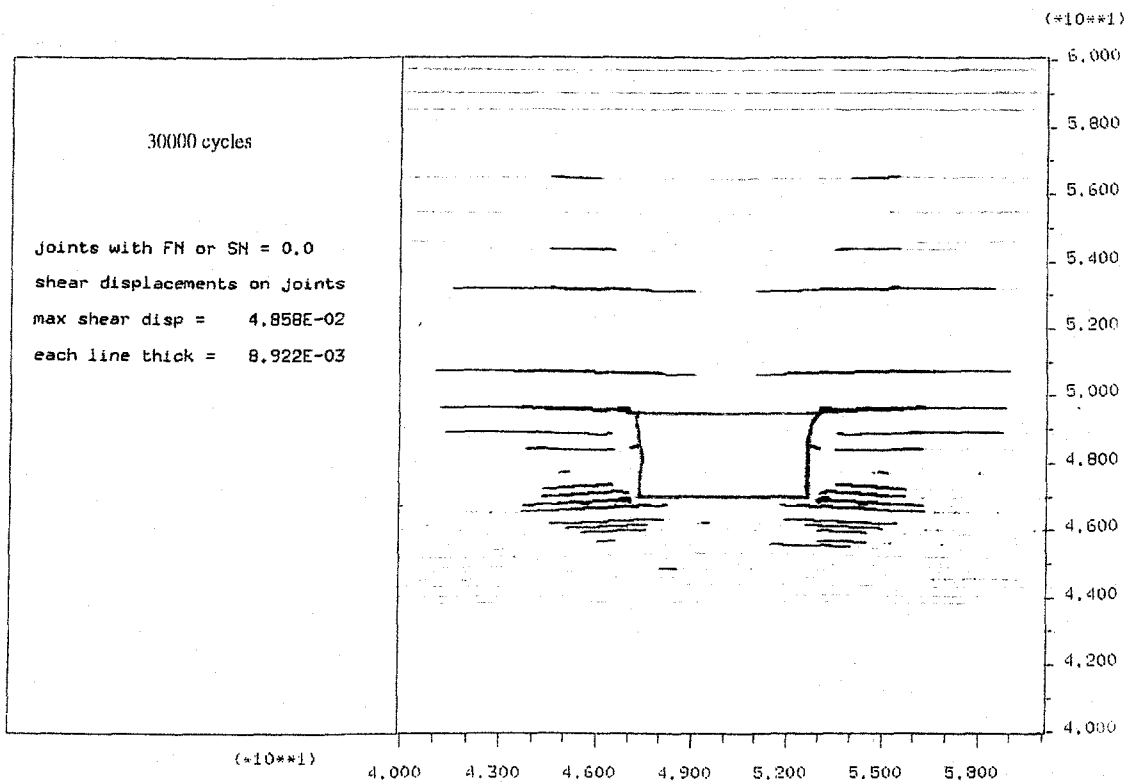


Fig. 7 : Shear displacements of joints without slotting and a vertical loading of 30 MPa



The high horizontal stresses are localised at the bottom and middle of the wall (60 MPa). Following cutting of the slot, these stresses fall significantly (40 MPa). The stress relief

introduced is of the order of 30%. This relief is not limited only to the wall. The facings are also stress relieved over a considerable distance (Figs. 8 and 9).

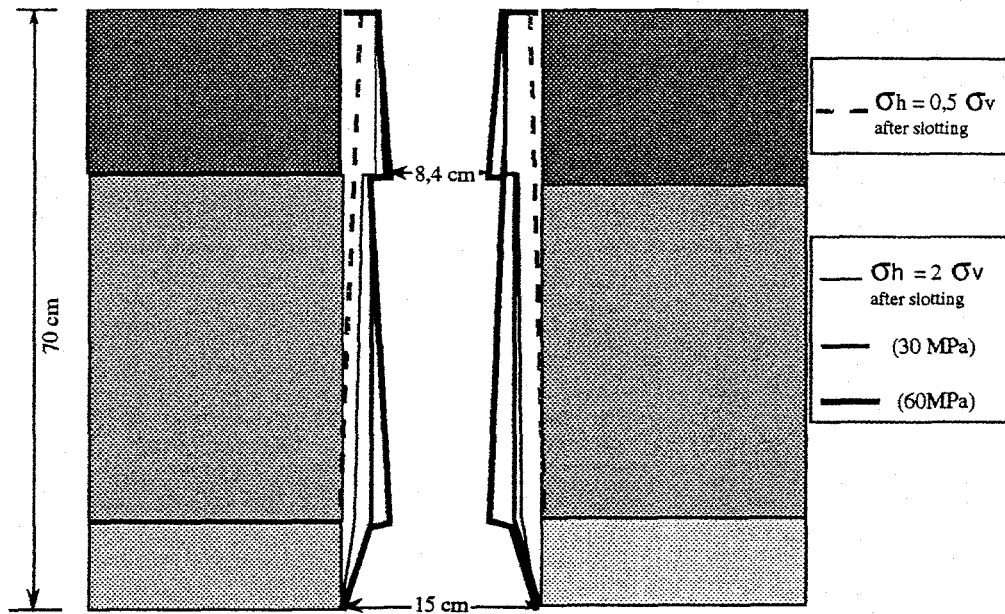


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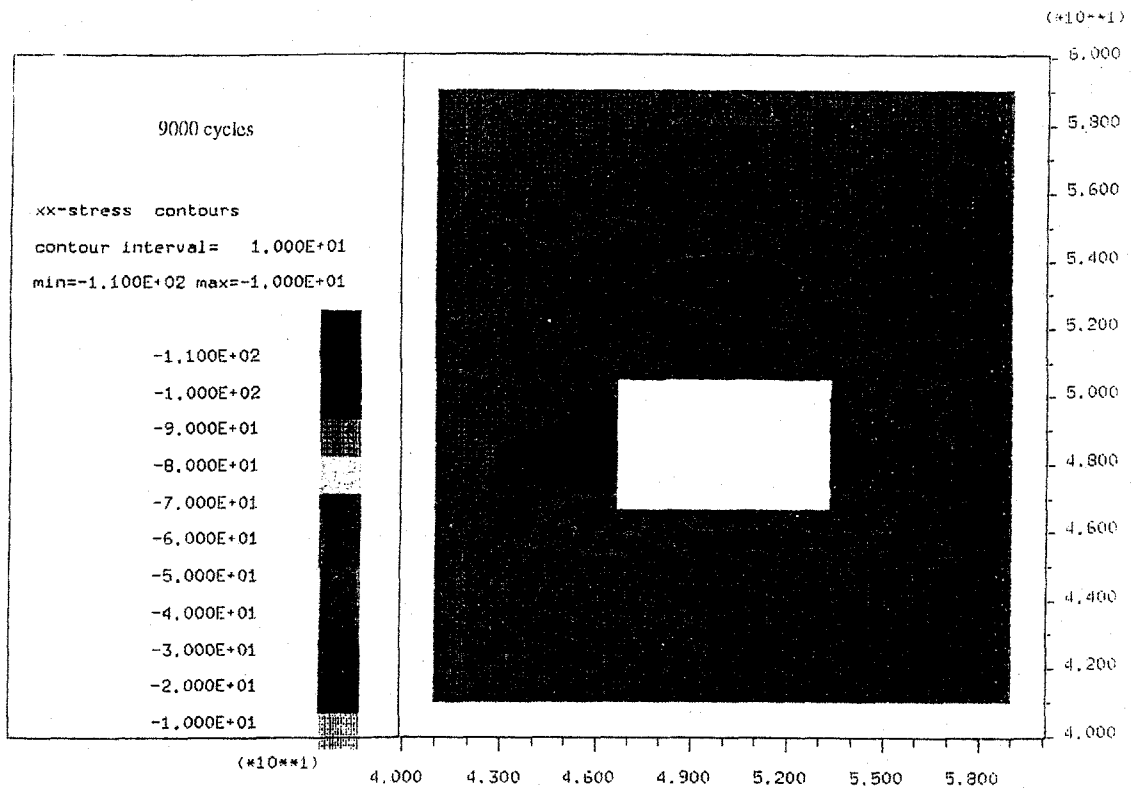


Fig. 8 : Contours of horizontal stresses  $\sigma_{xx}$  before slotting

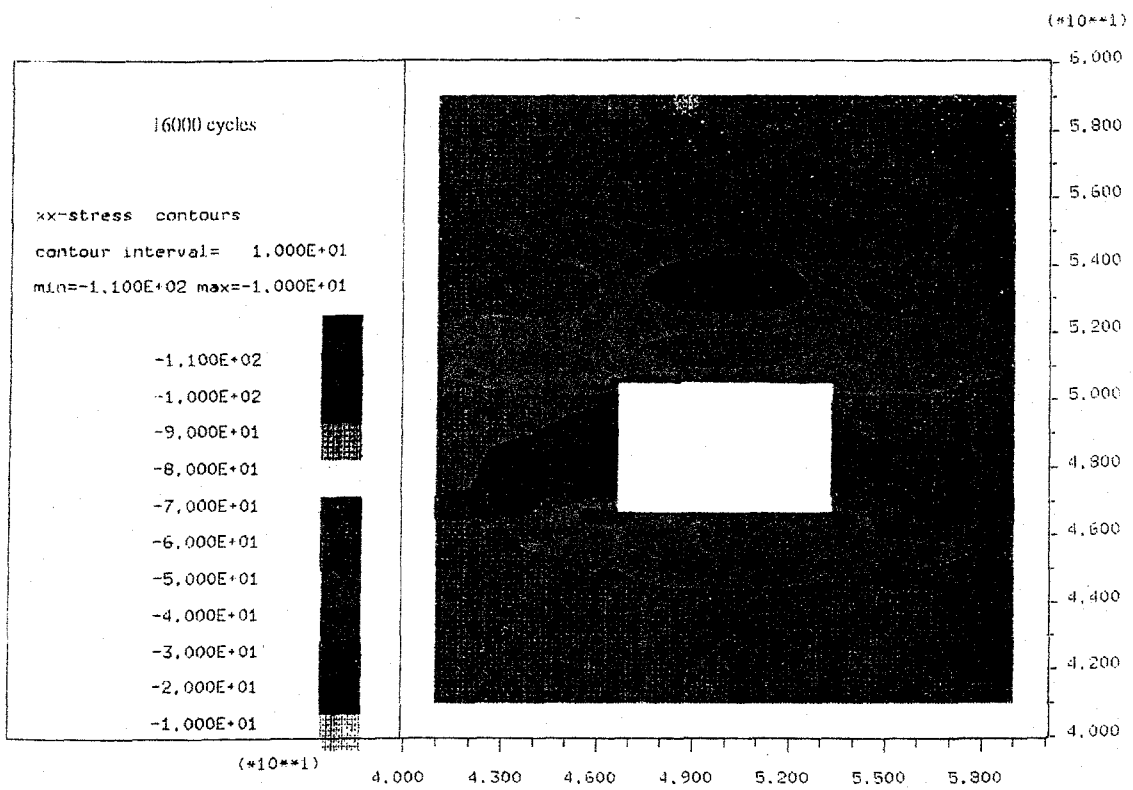


Fig 9 : Contours of horizontal stresses  $\sigma_{xx}$  after slotting