Retrofit of deteriorated structure due to rocket strikes

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Abstract:

A two stories building in Samawa City was struck by three rockets on March 2003.The building has been constructed from brick, unfortunately it experienced cracks in slabs and walls due to the strike of rockets. It is recommended to remedy and rehabilitate this construction for accommodation of Medicine College Deanship in Al.Muthanna University. In this paper remedy methods was presented considering the strengthening of the deteriorated members of the building and retrofit them. According to the analysis it was found that the proposed method for retrofit was a safe enough and economic one comparing with the new structure.

Keywords: Retrofit. Brick Masonry Walls, Bearing Walls, Reinforced Concrete Slabs, Reinforced Concrete Tiles, Highly Strength Concrete, Expansive Cement.

تأهيل منشأ متدمر نتيجة ضربة صاروخية

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الـخـلاصـــة:

بناية ذات طابقين من الطابوق تعرضت للقصف بالصواريخ خلال الحرب في آذار ٢٠٠٣ و قد تسبب ذلك في ظهور تشققات في السقوف و الجدران الحاملة لها نتيجة ضربات الصواريخ. تم اقتراحها كعمادة لكلية الطب في جامعة المثنى مما توجب إصلاحها و تأهيلها لتصلح لهذا الغرض. في هذه الدراسة تم توضيح طريقة المعالجة و ذلك بتقوية الأعضاء القديمة للمبنى و كذلك تجديد و أعمار الأجزاء المتضررة من الضربة الصاروخية و كانت الطريقة المقترحة أمينة و اقتصادية مقارنة بالإنشاء الجديد.

1. Introduction:

A building in Al-Samawa City was struck by three rockets on March 2003. This building is recommended to be rehabilitated for accommodation of Medicine College Deanship in Al.Muthanna University.

This building was constructed on 1974 on the left bank of the Euphrates River passing throw Samawa city. The system of construction was masonry brick bearing walls supported on strip footings bearing reinforced concrete slabs. The steel reinforcement bars were of smooth type.

Due to the strike of the rockets all concrete slabs experienced clear failure and this failure can be viewed in cracks pattern. In addition to the failure of the most of concrete slabs, the walls have cracks reaching to 50 mm in width.

As mentioned above , the main members of this building are the bearing wall of brick masonry, therefore, the study and remedial method was firstly concentrated on how these walls can be sustained the serviceability loading (dead load and live load) in the future life of the building after exploitation. It means that the principal way to get a strong enough structure is by strengthening the affected walls due to the strike and then

connecting them to the slabs generating good integrity between them. So, by this mean the building can be rehabilitated sufficiently and then after that the final retrofit shall be implemented.

2. The proposed method:

2.1: General Description:

The building is of brick masonry bearing walls and reinforced concrete slab system. The walls experienced severely cracks and also the slabs due to the momentum loads by striking of rockets (see **Figs., 1, 2, 3**). As shown in **Fig**. **3**, the walls are affected severely and it is required to be rigid enough.

Fig. 4 illustrates the schematic diagram of the plan of the main hall of the building and the approximate location of the rocket hit.

Fig. 1: Hole in the Reinforced Ceiling of the building

Fig. 2: Hole in the Reinforced Slab of the Main Hall in the building

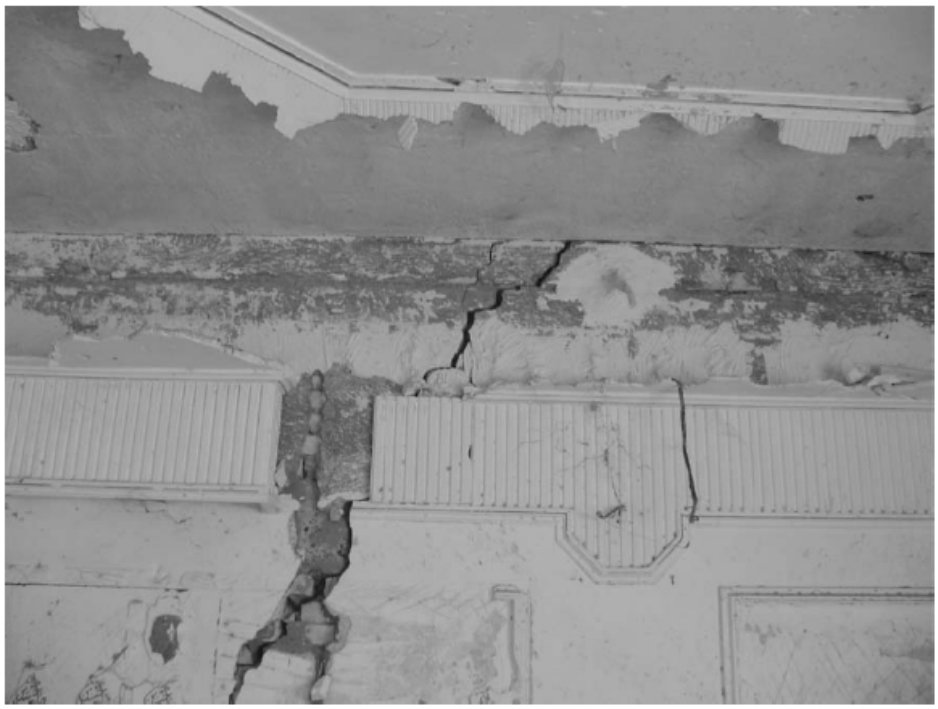


Fig. 3: Cracks in the Wall of Main Hall

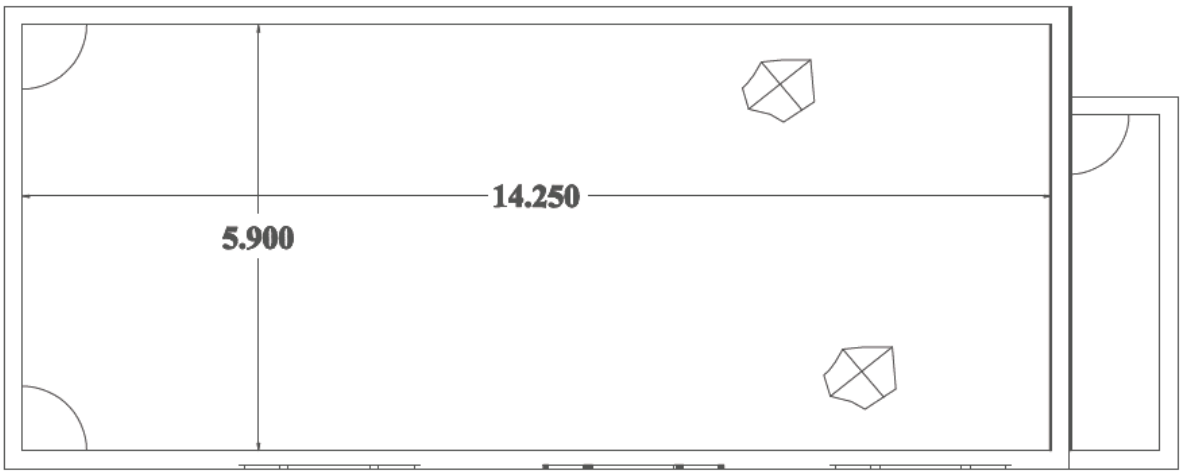


Fig. 4: General Plan of the Main Hall Showing the Location of the Rocket Strike.

As shown from the **figures (1, 2, and 3)** that the walls and the slab mainly affected by these strikes, therefore the paper will intensively concentrate to describe the methods which were analyzed and used to retrofit this construction. It is found that the cost of the rehabilitation equals to 1/5 of the cost for the new construction.

2.2: Wall:

For increasing the bearing capacity of the deteriorated walls (cracked one) and obtaining the good fixity with the roofing slabs, a reinforced steel bars will be

penetrated within the skeleton of the existed wall at spacing in transverse direction and these bars will connect with steel bars in the longitudinal direction in both sides of wall. The described mesh of steel reinforcement bars will erected and installed within thickness of 150 mm in each side. At the upper end of wall, where the slab seats, anchorage steel bars will be bent in elongation of the side concrete in order to insure the well connection between wall and slab (McCormack, 1984 and Wang and Salmon, 1985). The details are shown in **Fig. 5**.

2.3: Slab:

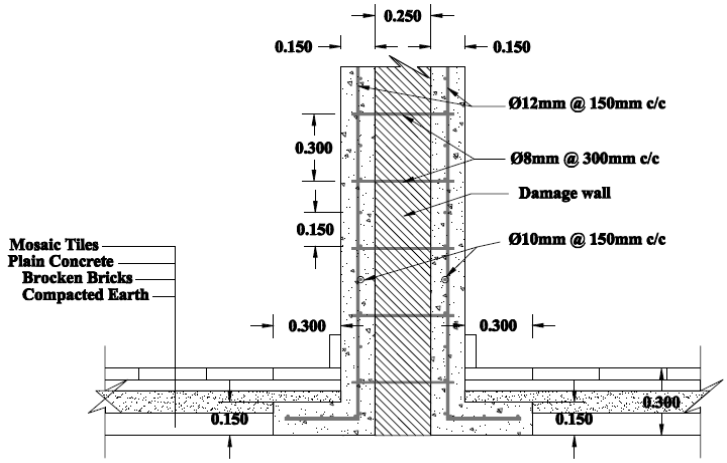
The stroked slabs shown in **Figs. 1 and 2** have holes due to the penetration of the rockets, it is obvious that these slab have cracks around the hole. This means that each slab firstly should have reconstructed its self and secondly supported by steel frame under each one. In addition to that the steel structure will has integrity point with the upper part of the walls (U.N.D.P, 1989 and Horii et.al, 1998). Therefore; to achieve the above scope, in this paper presented the patterns and arrangement of the steel structure and the details of connections between its parts and also the design of tiles that will accommodate to fill the holes in slab.

The full details of the above arrangement are shown in Figs, (6 and 7).

The analysis was conducted utilizing STAD Pro software, a typical analysis was shown in **Fig. 8**, and these calculations were expressed the safe suggested way for remedy. The details of analysis and design can be found in the technical report prepared by the authors which was financed by the department of engineering of the University.

The type of cement shall be used in casting the tiles and at the connection location shall be of highly strength cement (1987، الكود العراقي and 1987، ليفون و ساكو). This way will lead to ensure gain high strength at critical joints and connections and to increase the connection between old and new surfaces.

It can be emphasized on the good cleaning of all the old surfaces and increasing the roughness of these surfaces during the execution of the work (U.N.D.P, 1989 and 1978، الكود العراقي).



Lower End Detailes

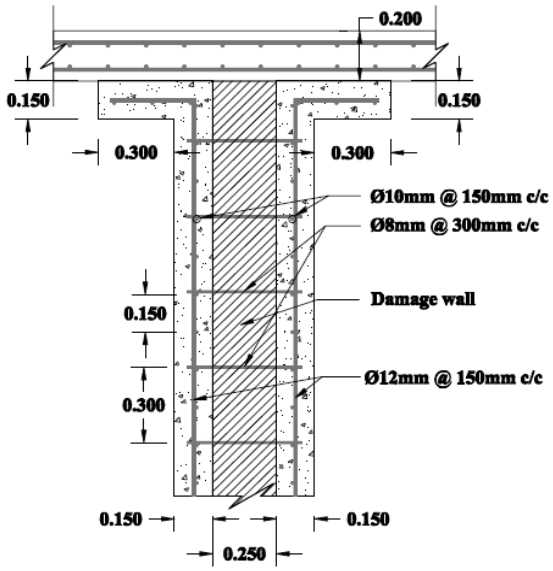


Fig. 5: Details of Strengthening of Walls of the Building

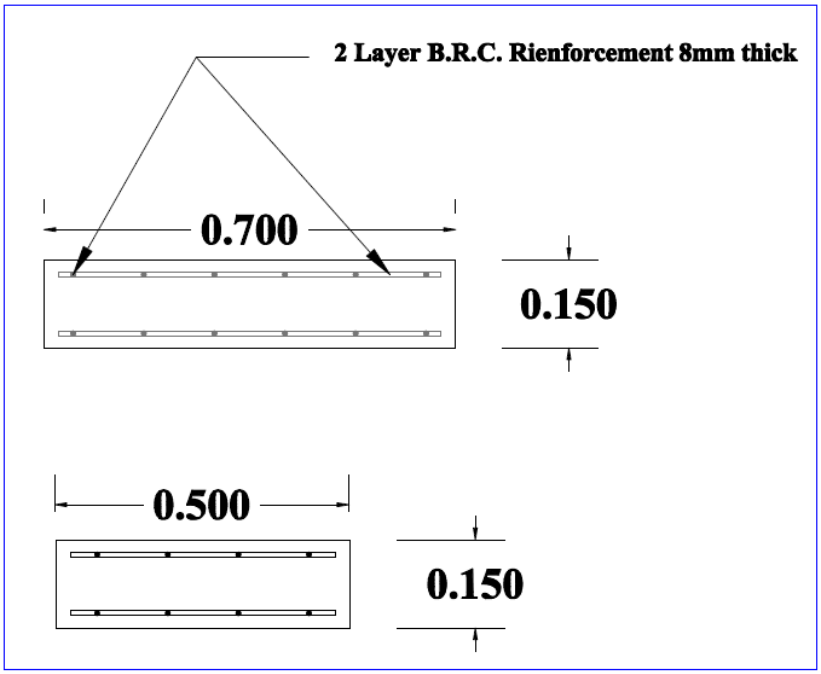
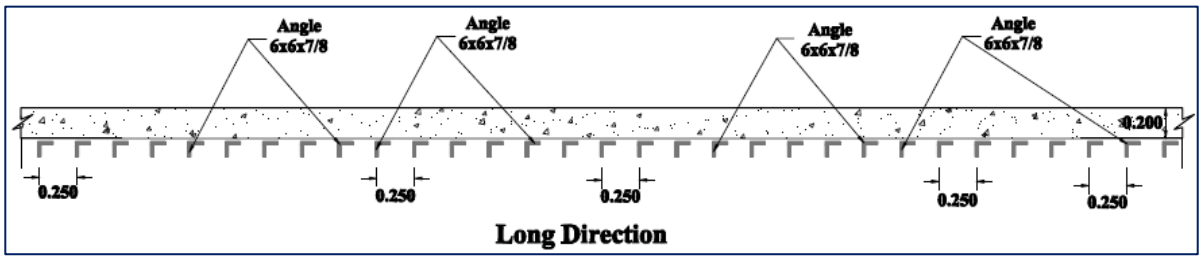


Fig. 6: Reinforced Concrete Tile to Fill the Hole in Slab



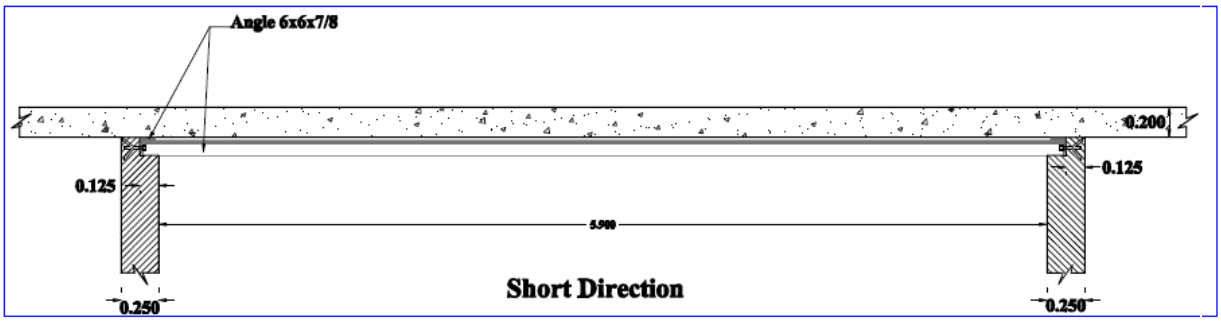


Fig. 7: Details of Steel Structure

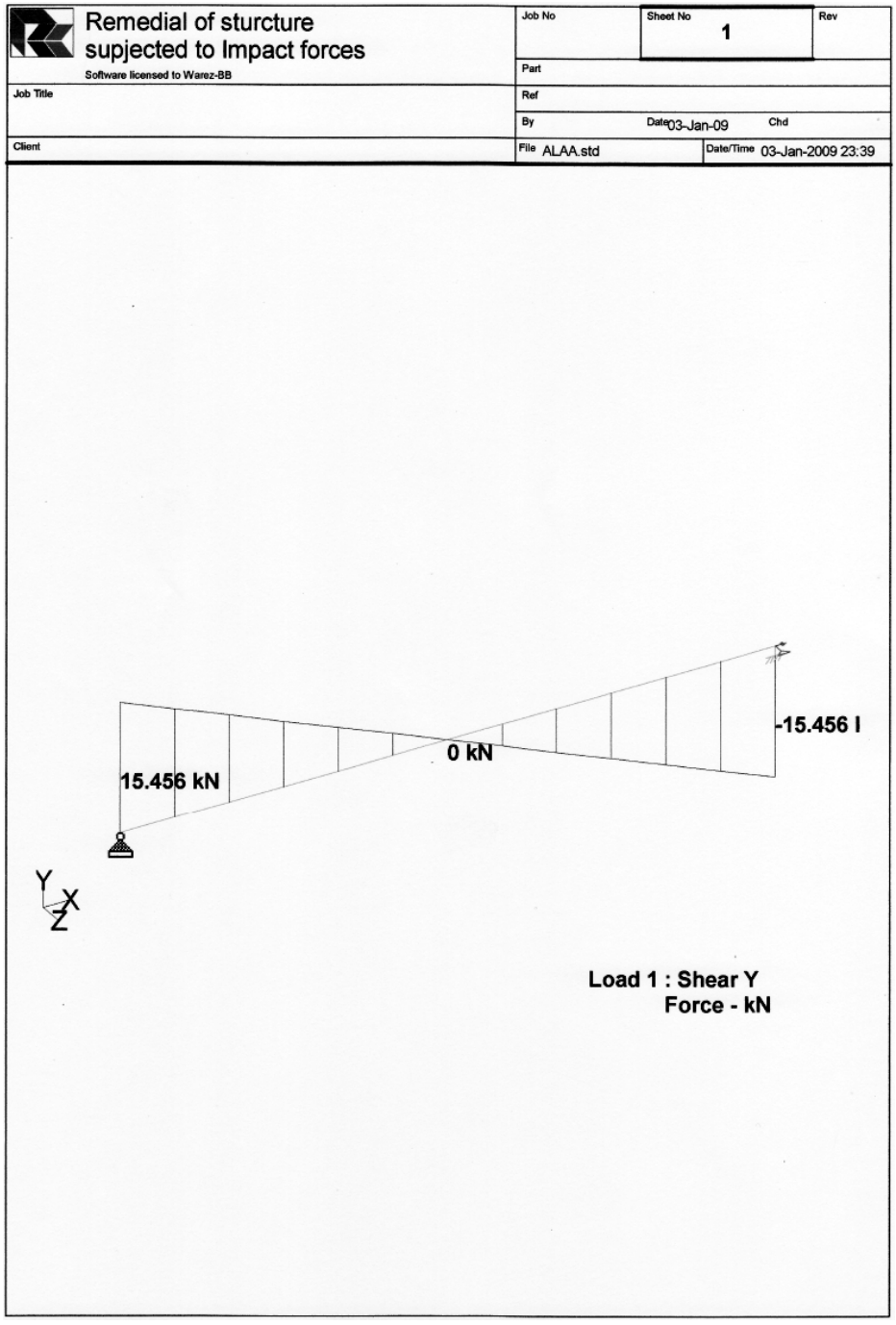


Fig. 8 a: The shear diagram for the beam under the slab

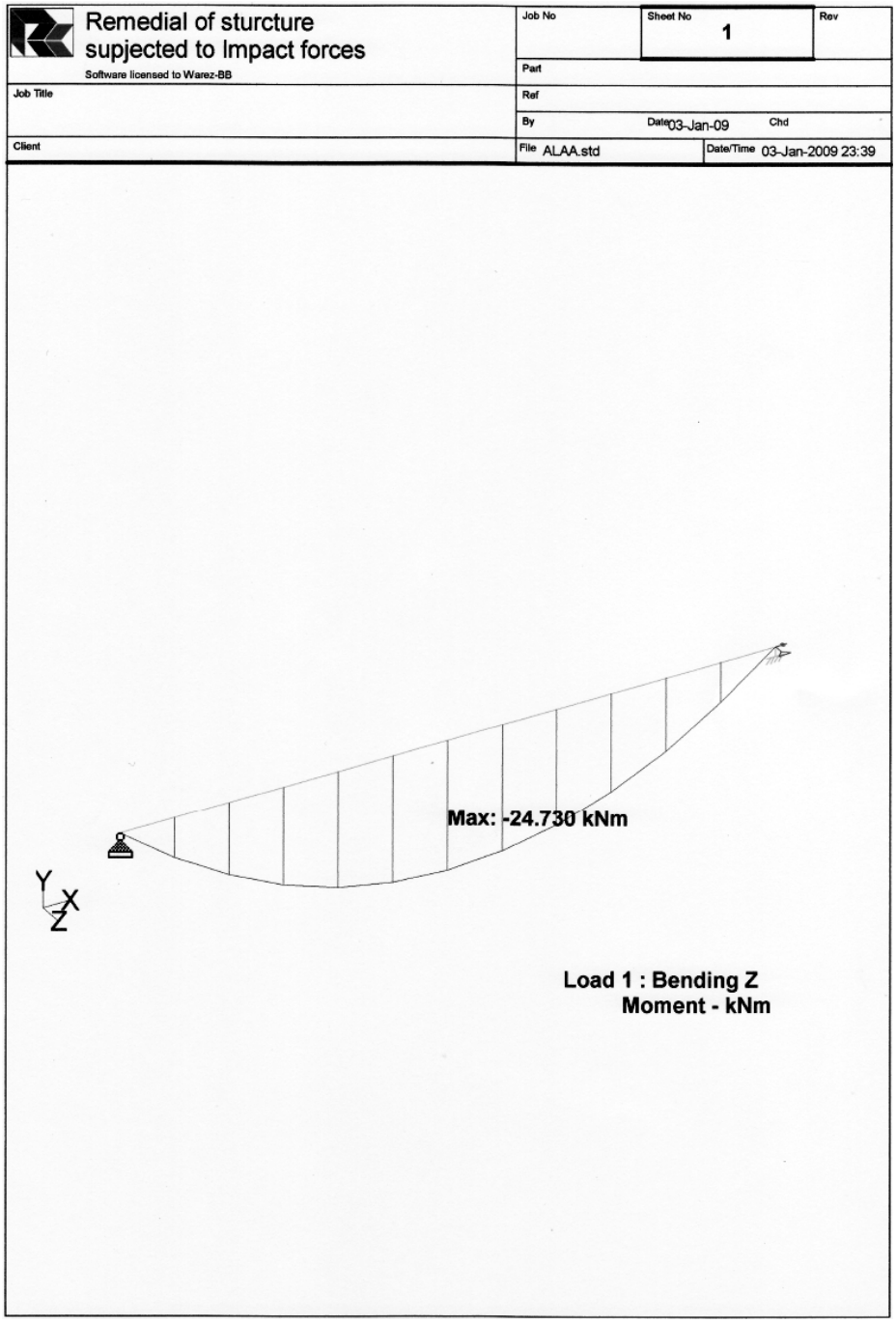


Fig. 8 b: The moment diagram for beams under slab

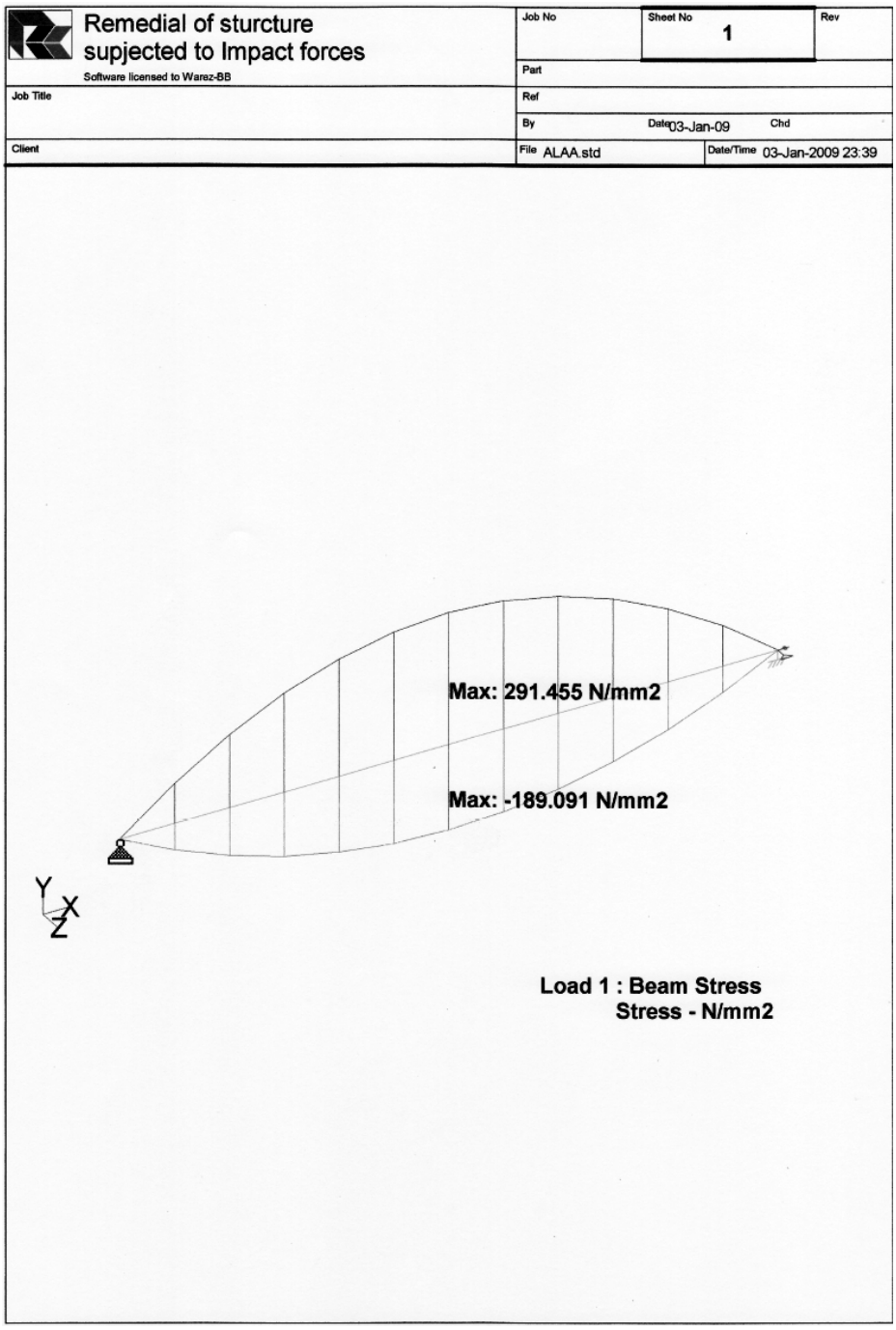


Fig. 8 c: The stress in steel beam under the slab

3. Conclusions and Recommendations:

1. From the photos and the visual inspection for the building, it can be concluded that the bearing walls are affected highly due to this strike.
2. Due to the rocket hit the slabs experienced punching shear and they are drilled to form holes.
3. The structural solution that was proposed was the best way for rehabilitate of the structure and to gain a rigid one.

4. At connection points between new and old surfaces and with the new structures it is recommended to use the expansive cement.

References:

U.N.D.P / U.N.I.D.O., Building Construction under Seismic Conditions in the Balkan Region Vienna, 1989.

الكود العراقي لمتطلبات الخرسانة المسلحة للمباني (كود ١٩٨٧)

آرتين ليفون و زهير ساكو (إنشاء المباني) بغداد، ١٩٨٧

Horii H., Kabele P. and Takeuchi S., On the Prediction Method for the Structural Performance of Repaired/Retrofitted Structure, Vol. 3, Proceeding of FRAMCOS-3 Conference on Fracture Mechanics of Concrete Structure, Freiburg, Germany, 1998.

Kosmatka S. H., Kerkhoff B., and Panarese W. C., Design and Control of Concrete Mixtures, 14th edition, Portland Cement Association, Skokie, Illinois, USA, 2003.

McCormack J. C., Structural Analysis, Harper and Row, Publishers Inc., N.Y. 1984.

Wang C. K. and Salmon C. G. Reinforced Concrete Design, Harper and Row, Publishers Inc., N.Y. 1985.