SITE SELECTION PROBLEMS IN GYPSUM-BEARING FORMATIONS. A CASE STUDY FROM NORTH OF IRAQ

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ABSTRACT

Gypsum is a well known problematic rock for engineering constructions. The Fatha Formation (Middle Miocene) is a widely spread formation in Iraq. One of its main lithological constituents is gypsum, beside marl and limestone, which occur in cyclic repetition within the formation. Due to high dissolving ability of the gypsum by water, different karst features are developed within the formation. These features, especially when are below surface, may cause severe damages to the constructions which are built on them. Detailed geological mapping of a site, north of Iraq, revealed many surface indications for detecting subsurface karst features that have caused true problems during excavation of the site.

مشاكل اختيار المواقع في التكوينات الجيولوجية الحاوية على صخور الجبس.
دراسة حالة موقع في شمال العراق

المستخلص

إن صخور الجبس معروفة بكونها غير صالحة للإنشاءات الهندسية . ان تكوين الفتحة (المايوسين الأوسط) من التكاوين ذات الانتشار الواسع في العراق ويتكون بشكل رئيسي من الجبس والطفل والكلس بشكل تتابعي. بسبب قابلية الذوبان العالية للجبس بالماء فمن الممكن تكون ظواهر عديدة من الكارست. وهذه الظواهر وخاصة عندما تكون تحت سطحية قد تسبب مشاكل كثيرة للإنشاءات.أوضحت المسوحات الجيولوجية التفصيلية لأحد المواقع في شمال العراق العديد من الظواهر السطحية يمكن استخدامها للاستدلال على ظواهر الكارست تحت السطحية والتي أدت إلى ظهور مشاكل كبيرة خلال الحفريات في الموقع.

INTRODUCTION

A site, located within Atshan anticline, west of Mosul town, north of Iraq suffers from subsurface karst features. These features are developed within the Fatha Formation that forms almost the bulk of the anticline.

The State Company of Geological Survey and Mining, on behalf of the Ministry of Oil carried out a detailed geological mapping for the site that covers one square kilometer, in accuracy of 1:5000. The main aim of the geological mapping was to evaluate the state of the site for construction purpose.

METHOD OF WORK

Topographic map 1:5000 on scale, especially concluded for the site, was used for the execution of the geological survey. The full mapping technique was used to conclude the geological map, with the help of a surveyor for assuring precise location of features that have special interest and which have been used in the

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evaluation of the site. Moreover, aerial photographs 1:42000 on scale were used for the interpretation and location of interesting features.

GEOLOGICAL SETTING

Atshan anticline is located within the Foothill Zone of Iraq (Buday and Jassim, 1987 and Al-Kadhimi et al., 1997). It is a NW-SE trending double plunging anticline, with narrow and long character. The southwestern limb is steeper than the northeastern one (Al-Jumaily et al., 1977) that makes the anticline in an abnormal position, concerning the symmetry, when compared with other anticlines in the surrounding area.

The Fatha Formation forms the bulk of the anticline and the site is located within the formation, which consists of marl, limestone and gypsum in cyclic nature. The gypsum is highly karstified forming large and irregular cavities, chambers and channels, with different sizes. The thickness of the gypsum beds varies from 1.5-12m, mostly thickly bedded to massive.

EVALUATION OF THE SITE

The site was studied and evaluated by a state contractor before its evaluation by the State Company of Geological Survey and Mining (Jassim et al., 1987).Nine boreholes were drilled by the contractor for site investigation purposes.

Unfortunately, the correlation of the boreholes was not done precisely. Therefore, the true extension of different rock types beneath the site was not detected. Moreover, the core description showed no indication for existence of subsurface karst features. The absence of gypsum beds was ignored, therefore the site was considered in a good condition and engineering works were carried out for leveling of the site, after excavation of huge amount of rocks.

After the execution of the detailed geological mapping in accuracy of 1:5000 (Jassim et al., 1987) for the site and restudying of the core, many subsurface karst features were recognized.The core study (Jassim et al., 1987) revealed that many gypsum horizones were not detected during drilling, because they were totally karstified and instead of them filling materials (mainly marl, claystone and limestone fragments) were observed. This was not detected by the first contractor.

Geological mapping of the open site and near surroundings revealed different features, which were found to be good indicators for the existence of subsurface karst features. These are described in the following article.

FEATURES USED AS INDICATORS

The main surface features used as indicators for the presence of subsurface karst phenomena in the studied site are:-

- **Concentric forms** (Figs 1&2). These are formed by layers of different rock types (green marl, red claystone and limestone) in concentric nature, giving them a ring form. The youngest rock being in the center of the ring.

  The diameter of these rings ranges from few meters up to 30m. They were formed due to continuous dissolving of the gypsum and continuous bending of other rocks towards the centre of the depression formed as a result of dissolution. This phenomenon was confirmed from recognizing the rocks along the banks of the site, formed after excavation of rocks for leveling purposes. The height of the banks reached up to 35m.
- **Disturbed limestone layers**. In normal cases any folded layer will obey the V-rule (Billings, 1964) when crosses a valley (Figs. 3 & 4). In the surroundings of the site many disturbed limestone layers were observed. They were not following the V-rule when crossing a valley. Instead of that different strange forms were developed, which are not structurally controlled. The only explanation for these abnormal disturbed limestone layers is the presence of subsurface karst features beneath them. This was also confirmed from recognizing the rocks along the banks of the site.
- **Rectangular forms**. In many places, surrounding the site, limestone horizons were observed to form rectangular and/or zigzag forms (Fig. 4). Usually with very steep inclination towards the center of the rectangular form. The only explanation for these forms is the presence of a subsurface karst feature beneath them. The acute or vertical bending of the beds is attributed to the presence of two sets of joint (almost perpendicular to each other) or small faults. Unfortunately, no opportunity was found to confirm this assumption, because their subsurface extension was not present at the banks of the site.

STATUS OF THE SITE

According to the first state contractor, the site was considered to be in a good condition, they have not detected the subsurface karst features, which were almost filled by inhomogeneous materials. Moreover, the absence of gypsum beds (Figs. 5&6) in the extracted core from drilling of nine boreholes, encouraged such evaluation of the site.

Ignoring of the aforementioned two important factors and non-reporting them caused true problem to the site designer (personal communication with the Yugoslavian team, 1987). This was discovered only after extraction of huge amounts of rocks for leveling purpose of the site (Fig. 6).

According to Jassim et al. (1987) the site was in a bad condition and it was recommended to be abandoned. This was concluded due to the presence of dense karstified gypsum beds, beside the presence of thick gypsum beds in alternation with marl and limestone (Fatha Formation). This alternation of competent and

Fig. 1 : Circular ring form in limestone beds

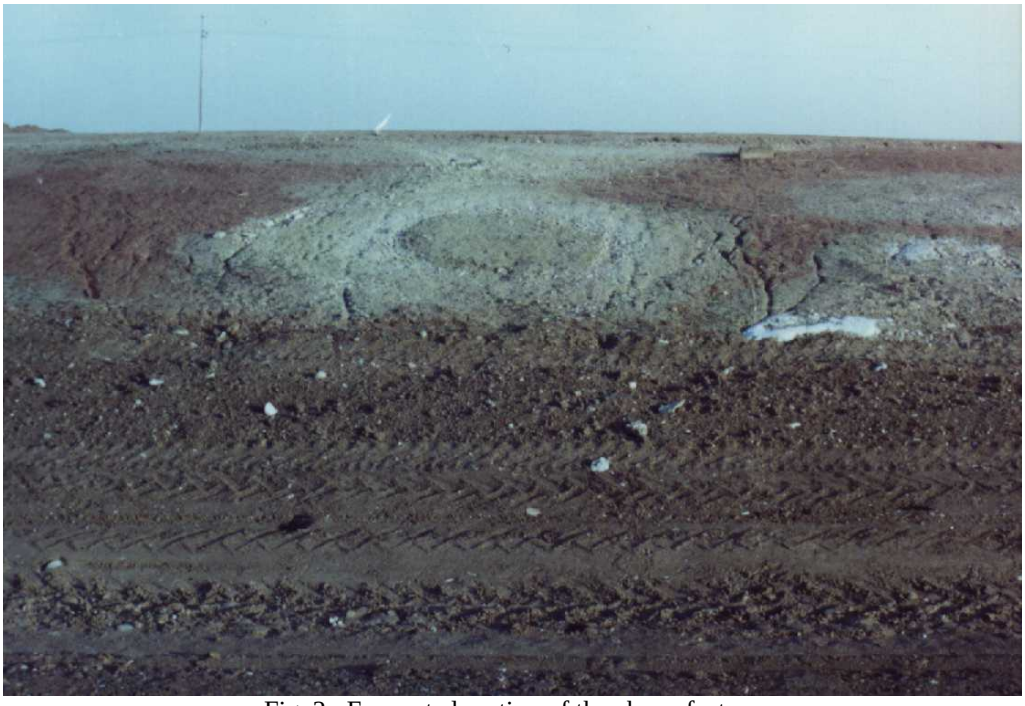

Fig. 2 : Excavated section of the above feature

Fig. 3: Limestone beds dis-obeying the V-rule.

Fig. 4: Limestone beds forming zig-zaq and rectangular forms

Fig. 5: Karstified gypsum. Note the absence of the gypsum in certain areas and the ring form on the upper right corner (on the surface)

Fig. 6: Large karst, in the floor of the centre of the main site.

incompetent rocks is not a favorable condition for foundations, especially when it is unidentified.

The site designers accepted the geological map and the enclosed report (Jassim et al., 1987) of the site. Depending on the presented geological map and enclosed report that explains the true status of the rocks in the site, the design of the site was rearranged and it was constructed and used successfully.

CONCLUSIONS AND RECOMMENDATIONS

The following can be concluded and recommended:-

- The presence of gypsum beds is usually problematic and not preferable during site selection
- The aforementioned surface features are very good indicators for the presence of subsurface karst features. They could be very easily recognized during the interpretation of aerial photographs and/or during reconnaissance trips for preliminary site selection.
- Although the true depth of the karst features could not be determined, from the surface features, but it was found that they occur 5-35m below surface and may be more. The size of the forms and their degree of inclination towards the centre could be used as rough parameters for depth indication.
- It is highly recommended not to select a site within gypsum rocks, especially when the aforementioned features are developed in the site. However, when the site can not be avoided, reporting about the true status of the site, concerning the presence of subsurface karst forms will help the designers of the site to take them into consideration.

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