Effects of increasing distance of columns in reinforced concrete water storage tanks

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ABSTRACT: This is a case study concerning effects of increasing internal distances among columns in 87500 cubic meter reinforced concrete water storage tank in Water supply to petrochemical special zone area project in Iran. In this project engineers were asked to research and find which distances among columns is more efficient to construct water storage tanks and what are the effects of increasing distances from normal distances (about 4 to 5 meters) on walls, roof and slab of storage tank. To investigate the possibility of increasing the spaces among columns and the effects new models were created in the SAP application and these variations were investigated. Finally the effects of these changes on bending moment and internal forces was calculated and the results analyzed. The significant effect of column numbers and their distances on thickness of walls and roof and the reinforcement of them carried out.

1 INTRODUCTION

These days lifelines play very important roles in human life, drinking water storage tanks are one of the most significant parts of water distribution systems. There are different regulations to design water thanks in various countries which are concerned different values and limitations to design and controls water tanks safety. Reinforced concrete tanks have been used for water and wastewater storage and treatment for decades. Structural engineers were required to design a variety of square, round, and oval reinforced concrete structures that may be above, below, or partially below ground. Design of reinforced concrete tanks requires attention not only to strength requirements, but also to crack control and durability. To investigate the possibility of increasing the spaces among columns and the effects new models are created in SAP application and these variations are investigated.

Finally the effects of these changes on bending moment and internal forces are calculated and the results analyzed. This storage has more than 20 segments but just segment A1 Figure 1 is studied as an example because each segment individually could reveal those effects which were considered. With increasing distances among columns from 5 to 6 m and 6.25 m, obviously some changes happened on the geometry of the reservoir, loads and bending moments of reservoir's elements, the purpose of this research is to study these changes, and compare results of these changes. The models are applied with similar loading, load combinations and analysis. Water level in the reservoir is 6.2m Static and dynamic forces of water have been calculated on this level by considering the Iranian code to calculate and design a water storage tank (Code 123) 40cm thickness walls and floor and roof thickness of 25cm are taken. Reinforcement area in these models was designed based on ACI. Design and load combinations were based on ultimate strength method.

The specific compounds studied here, including dead load, live load and lateral seismic forces and dynamic forces. There are 25 columns in this segment which were located in 5 m distances in two ways and the length of shear wall is 5 m. The surrounding wall has 7 supports in one way and 6 in another, in the second model distances are increased to 6 m and 6.25 and supports decrease to 6 and 5 respectively.

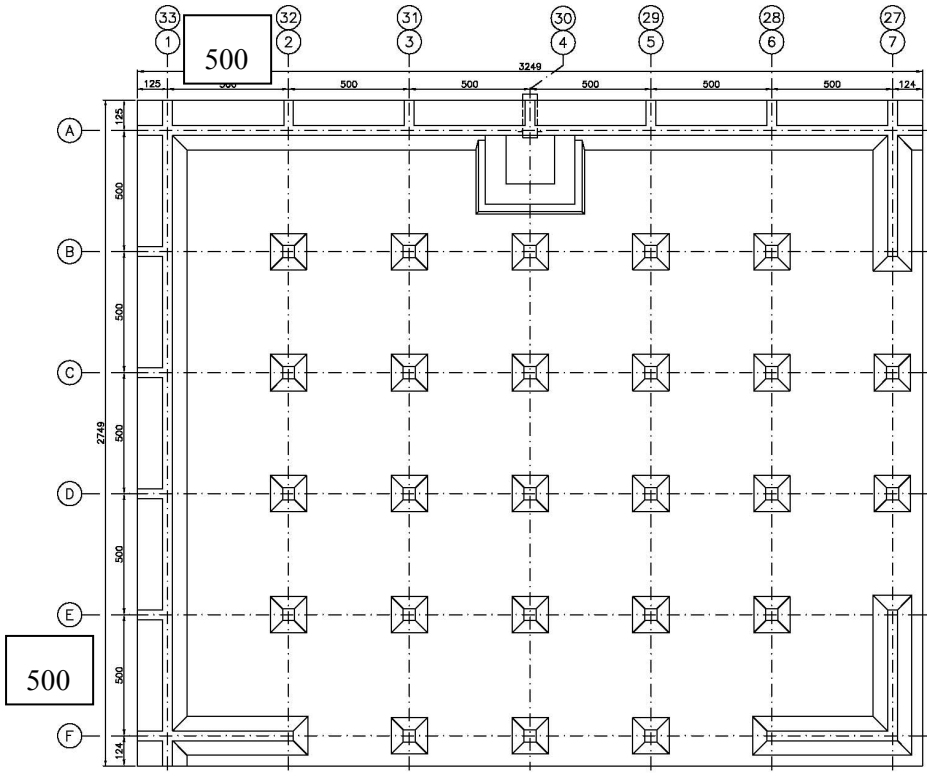

Figure 1. Segment A, Storage Tank- First Model

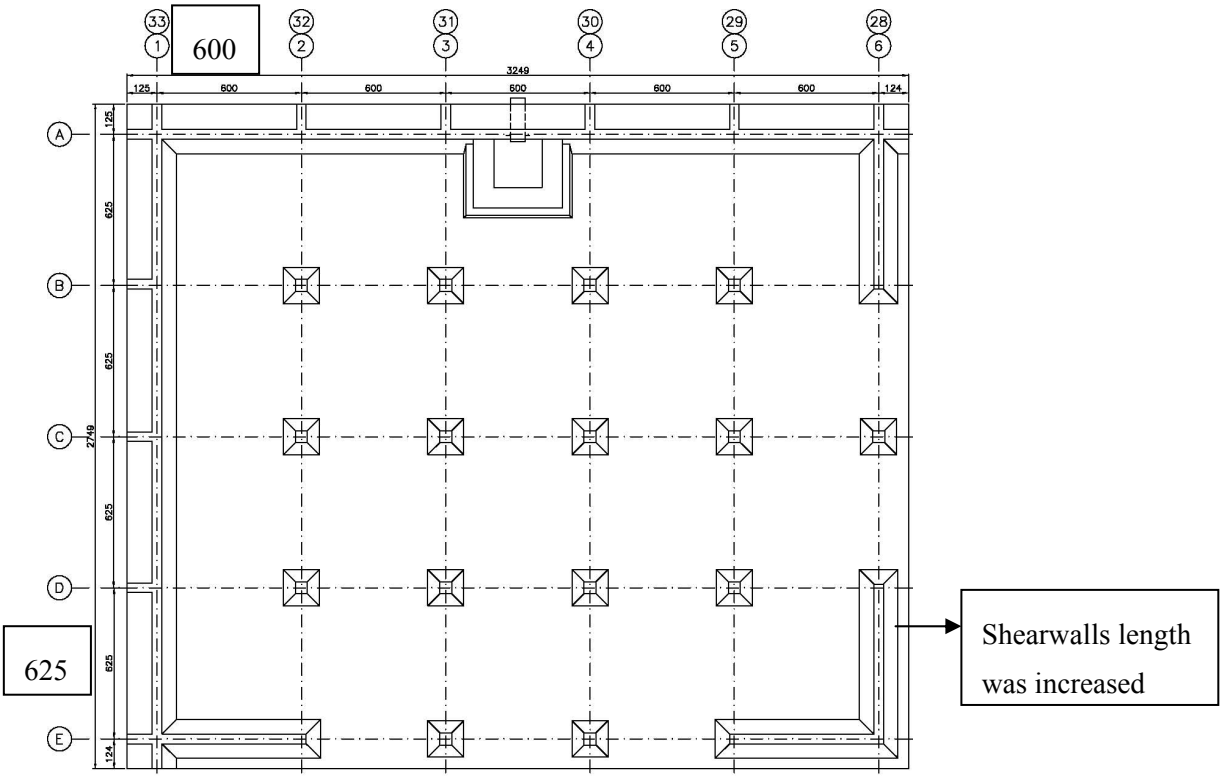

Figure 2. Segment A , Storage Tank- Second model

2 GEOMETRIC CHANGES

Comparing Figures 1 and 2, increasing in the distance between the columns lead to a decrease in the

number of columns and the growth in the length of shear walls is notable. The number of columns reduced from 25 columns to 15 columns, but in order to preserve the symmetry of the reservoir geometry, there is also a need to maintain equal intervals in the roof. It is essential to increase the length of shear walls in both directions to prevent more deflection of the roof slab as the reason of deleting columns on increasing bay of loading on roof slabs. For example, the length of shear walls in this segment increased to 4.5m, and this increase in the number of columns didn't has significant effect in the volume of concrete and reinforcement.

2.1 **The effect of increasing distance among columns at the bottom slab of the tank**

At the bottom slab moments in different areas increased and this increment is about 10 tons - meters in some areas, equivalent to an increase of 9 m^2bars area per one meter. For example, in the mentioned area (Figures3 & 4), moment increased from about 30 ton-meter at first model to about 40 ton-meter, actually, the amount of reinforcement required increased from 27 $m^2$to 36 m^2 (equations based on 123 code).In fact, an increase of about 30 percent of the required reinforcement routes. Certainly the moment increase in area of between columns had maximum changes and under column was less. This change happened for positive and negative moments and affects both above and below layer of the bottom slab's bars.

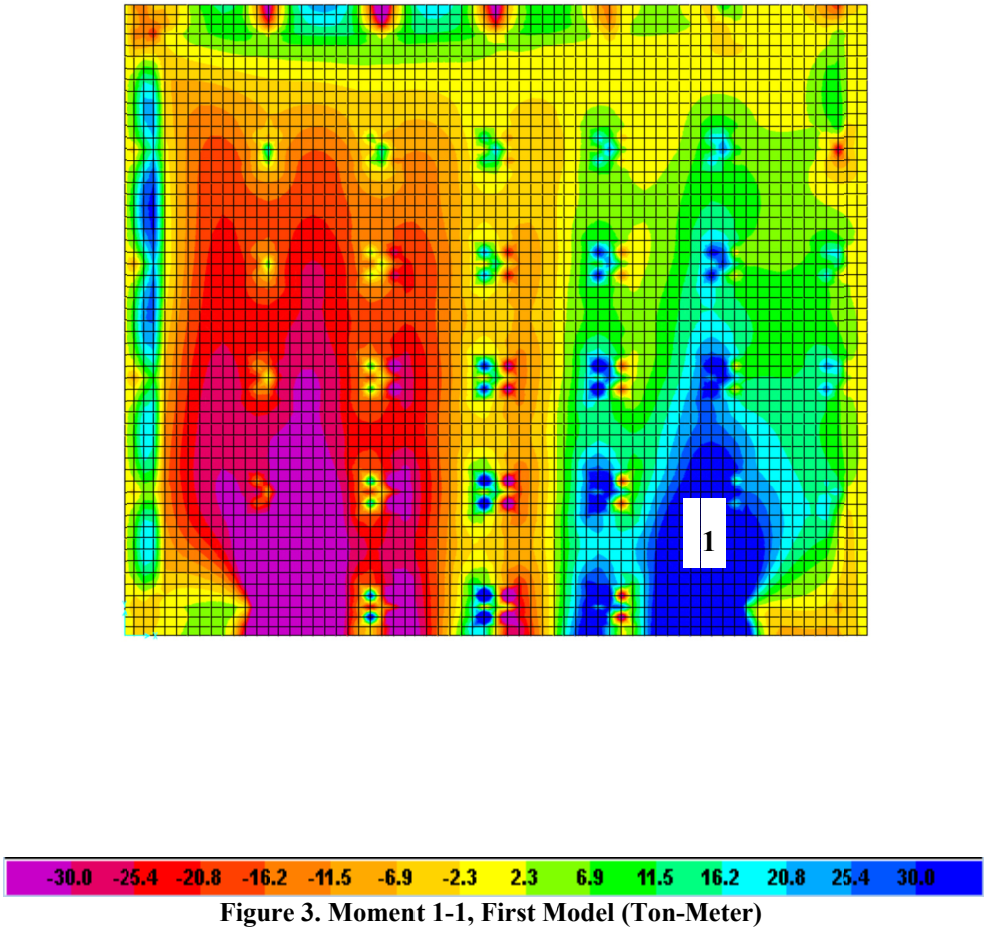

Figure 3. Moment 1-1, First Model (Ton-Meter)

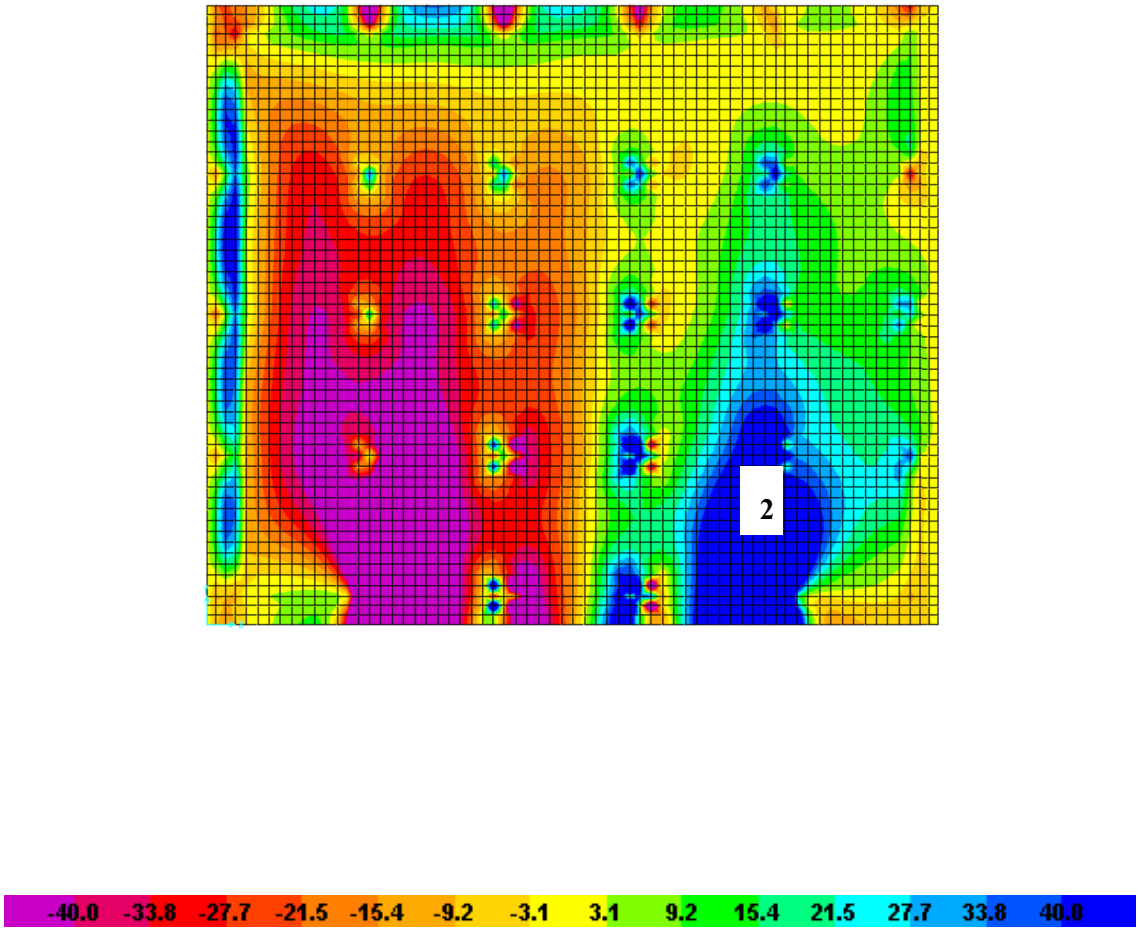

Figure 4. Moment 1-1 Second Model (Ton-Meter)

2.2 **Effects of rising distances of columns at roof of storage tank**

Due to the low thickness of the roof, increasing distances of columns had the highest effect on roof. Width loading was increased from $25m^2$ to $37.5m^2$and moment rose approximately 35 percent. The average increasing of percentage of bars was different from 10 to 35 percent. For example, in the area shown in the (figures5&6), moment increased from about 5 ton-meter at first model to about 8 ton-meter,. Increasing the distance between the columns and rose impact load on roof leads to more bars and, if insufficient thickness of roof is considered necessary to increase the thickness of roof, so due to increase of thickness, all static and dynamic loads increase and obviously more bars must design to tolerate moments due to these increments.

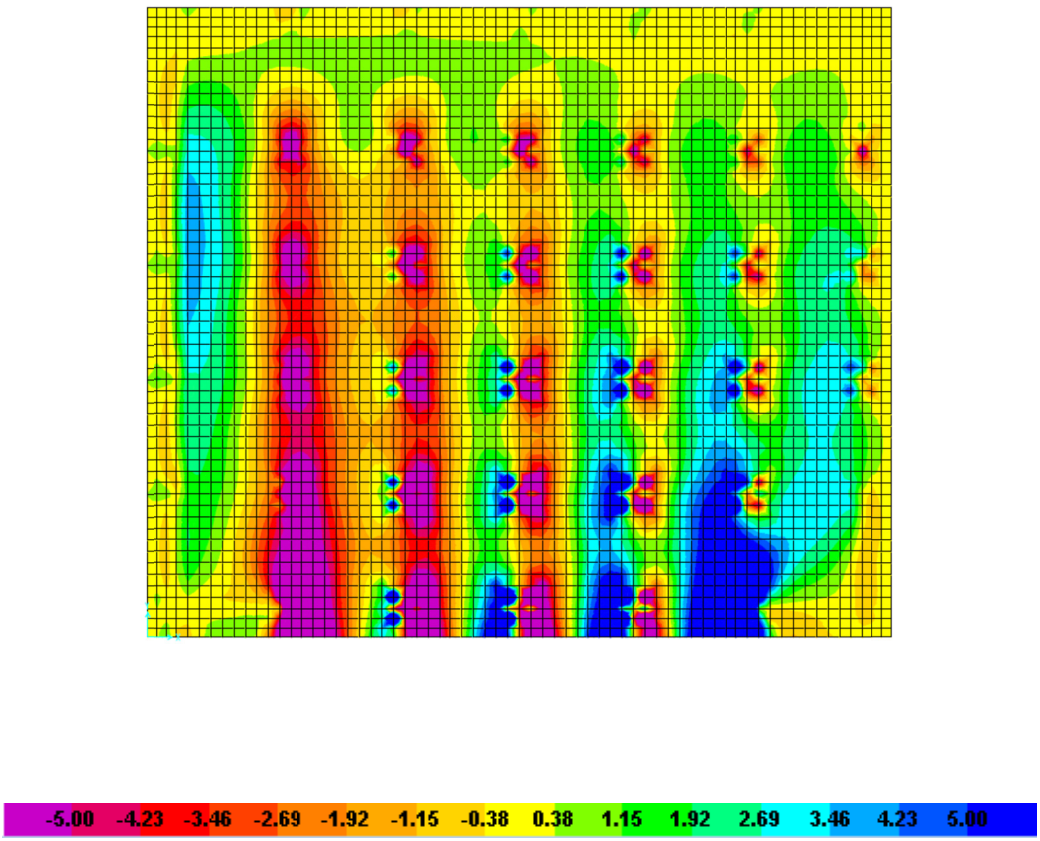

Figure 5. Moment 1-1, First Model (Ton-Meter)

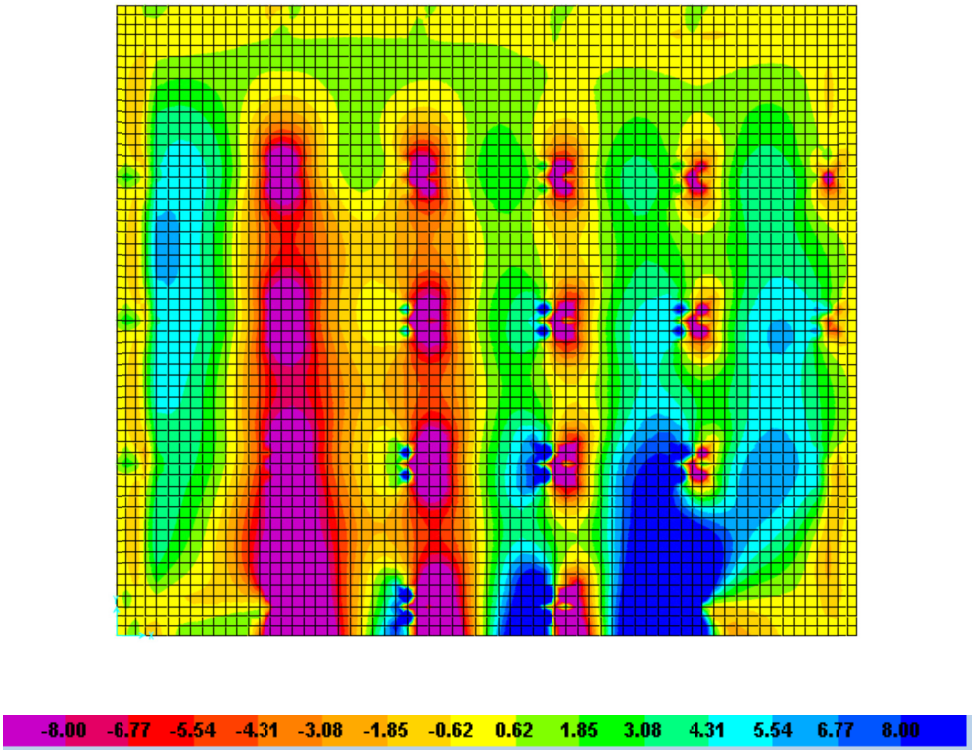

Figure 6. Moment 1-1, Second Model (Ton-Meter)

2.3 **The effect of increasing the distance among the columns on the walls**

Increasing distance on the walls also affects surrounding walls and increases moment to 4 ton-meter. For example, moment at 2-2 direction was increased from 12 ton-meter mention at figure 7, to 16 ton-meter. These changes indicate an increase of about 30 percent of the required bars in the walls.

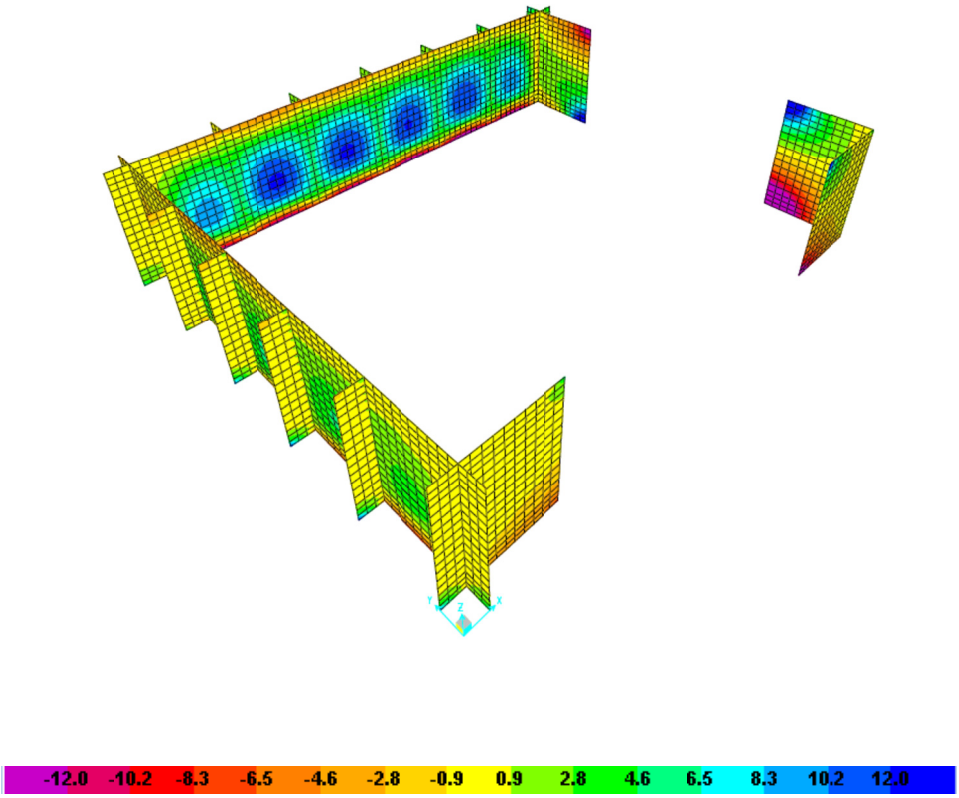

Figure 7. Moment 2-2 , First Model (Ton-Meter)

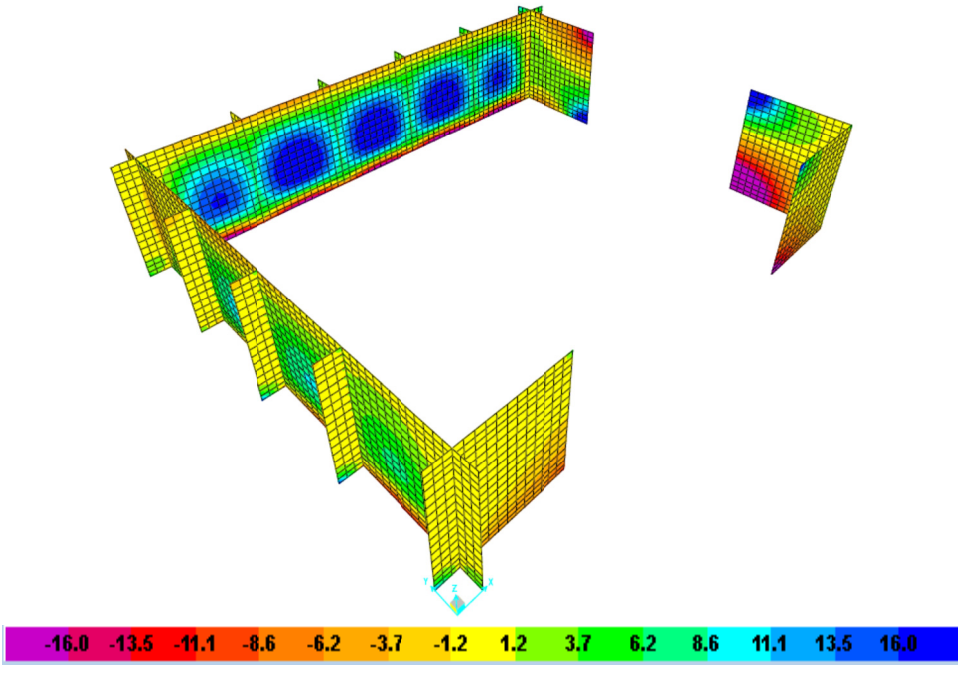

Figure 8 . Moment 2-2 , Second Model (Ton-Meter)

3 CONCLUSION

In rectangular reinforced concrete water storage tanks shell elements must resist lateral loads, static pressure and dynamic load due to water height , shear walls help this system to resist dynamic loads, columns must tolerate the gravity loads and also any loads due to water pressure, most of regulations introduce some regular distances for column placing in tanks as the results of various designing and construction of water tanks, but a little studies has been done on optimization of these distances and effect of that on total costs of construction. Comparing the two models, it can be concluded that increasing distances between the columns, some changes happened in the distribution of forces on elements and their portion from forces. Increasing distances does not help us to decrease the bars areas which are required because on the other way we have to increase the length of shear walls or supports and so it does not have any efficient effect. Generally, in most area, it can be observe that an increase happened in moment which leads to the increase of bars quantity. Increasing columns distance will reduce the quantity but at the same time areas of reinforcement bars the quantity will increase.

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