Resilient Structures and Sustainable Construction
Edited by Pellicer, E., Adam, J. M., Yepes, V., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-4-8

SPIRAL PARABOLIC DOME: HISTORICAL STUDIES OF IRANIAN ARCHITECTURE

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Ancient Dezful city is located in the SW of Iran (5000BC-2016AC) near Dez River. This spiral domes are used to demonstrate the symbolic special constructions which is similar to the construction of Denial's holy shrine, the Jewish messenger (500BC), the Lion King Yaghob Saffari's tomb (800AD) and the Rood-band Syd's burial place (1409AD). These structures are made by simple local materials. The common materials used are bricks and Sarooj mixture. Sarooj is the main mortar, a man-made concrete. After thousands of years, it still stands all kinds of tension, pressure, wind, rain, conflicts and wars, weapons and rockets effects (1980-1988), and sewage exposure. All bricks were set to demonstrate the cubic elements around the spiral curve. It turns around circles with variable radiuses on the spiral path- line which makes a conic parabolic sharp dome. Two domes constructed in each parabolic dome. The first dome is fixed between the supports that are called the inner dome. It was erected on the semi sphere space. The second dome is constructed by the parabolic conic section to demonstrate a beautiful, cultural and architectural masterpiece of engineering. The Main materials are bricks, dolomite, canes, stone blocks and Sarooj, a special mortar. The height of the Spiral Parabolic Dome (SPD) is about 10m and the radius of the inner dome is measured about 2 m with a ratio of 2.5 that would vary with the Geo-technical conditions and the architectural considerations.

Keywords: Conic dome, Bricks, Sarooj mortar, Dezful, Tomb, Semi sphere dome.

1 INTRODUCTION

The current study focused on the conic domes that have been put up in the ancient city of Dezful more than 1000 years ago. The ancient Persian Tombs and Mosques represent the culture and the memory of the old Kings (Kiani 2009). The structures had to be made strong enough so that they would resist the weather and the invaders' vandalism over centuries (Pirnia 2009). The geometrical design stands for the culture, the architecture, and national crown symbol. The materials, which have been used in the construction of Tombs, were bricks, stones, and Sarooj mixture. The main Spiral Parabolic Dome (SPD) geometrical ratio is the crown slenderness coefficients. It can be determined by the ratio of the crown height over to the inner dome radius which is approximately about 2.5 to 3.0 for mentioned structures. A semi-spherical dome must be confined to transfer the SPD loads into the inner dome and the Reaction Stone Walls, Figure 1 (Puller 2003). Therefore the SPD was built in octagonal form (the eight edges or Hashtpar faces in inner Dome). Figure 1 shows the octagonal edges or Hashtpar Reaction Design (Ridly 2001).

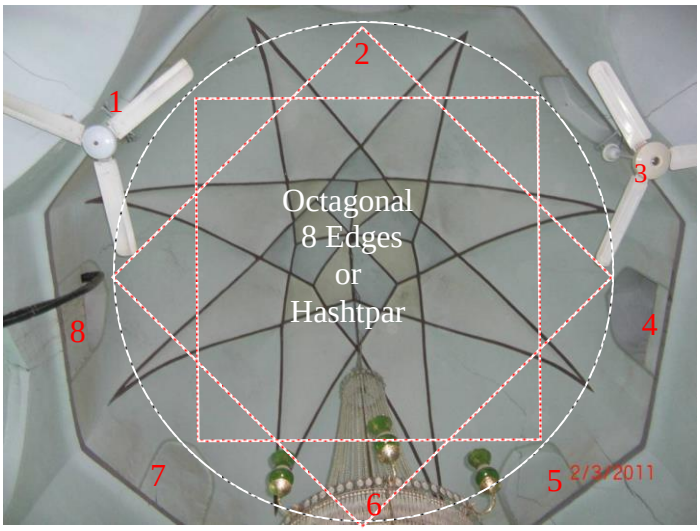

Figure 1. Octagonal faces stable to distribute loads.

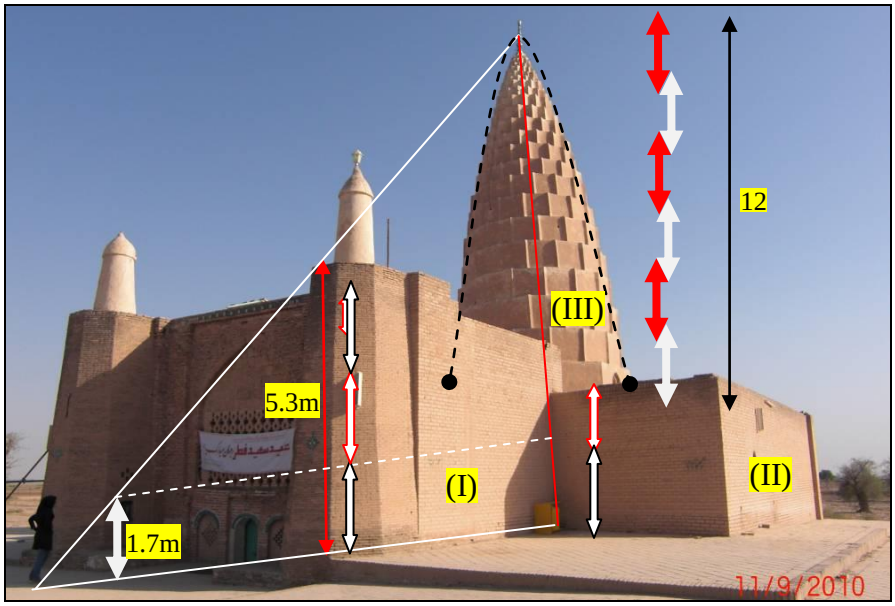

Figure 2. Tomb of King Lion Yaghob Saffari (800 AD), 15 km from Dezful.

2 DRAWING

Figures 2 to 4 represent the common shape of the Tombs with SPD diagrams. The total height of the dome structure is measured more than 15m from top to the baseline level. In Figure 2, the Lion King Yaghob Saffari's tomb –LKYS- shows the dimension lines and the scale indexes. Part (I) is the entrance of the Tomb that holds one third of SPD load. Part (II) is the Prayers hall and the place for the seating of the Lords. It is usually designed to receive two third of the total SPD load. The main materials are used in part (II) which are stones and pebbles with the Sarooj mixtures. This part must constrain the inner conic dome to transfer the load. As Figure 3 shows, bricks appear with variable block sizes. The Blocks weight increases from the top to the bottom.

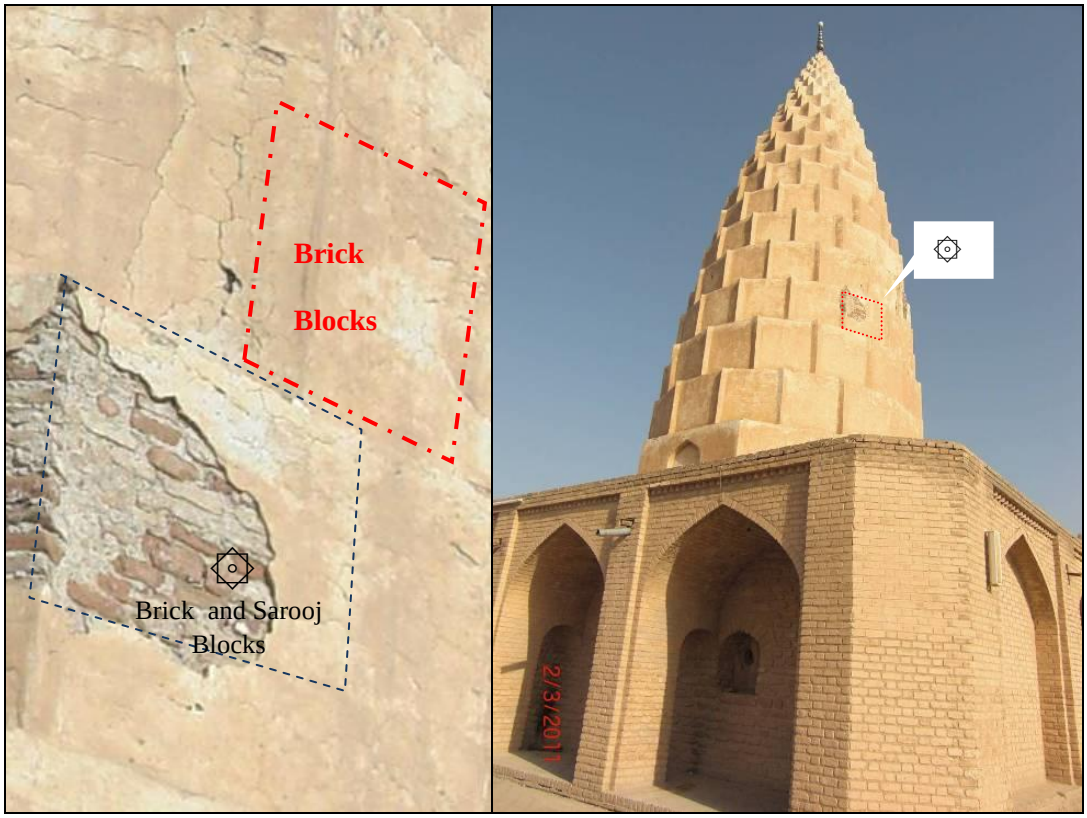

Figure 3. Spiral parabolic dome structure with brick blocks and ancient Sarooj mortar.

2.1 Step Block Drawing

The SPD passes on a spiral path to complete each pitch by step shape brick- blocks (demonstrated in Figures 1 to 4). As Figure 4 demonstrates, in order to show the spiral path of different blocks, the blocks are numbered. First block is numbered 1 that starts from the top of dome and continues to number 19. Block No. 20 is the final one and it is the main support of the structure. It can transmit the dome loads into the foundation. The octagonal (Hashtpar) semi spherical was used to complete the dome structure in ancient Iranian architecture. The total SPD faces are composed of 14 spiral blocks, from block number 2 to block number 19. Blocks number 15 to 19 surround the semi spherical dome. Figure 5 shows that, the main Sarooj mortar is used in wide walls and foundations. The Sarooj is used to construct dams and water supply structures. It is a mixture of the animal fat, ash, sand, gravel, dolomite and especial burned clay. The maximum strength of Sarooj is measured more than 400 kg/cm^2. Currently, the mixture and design of the Sarooj is unknown that makes it necessary to test it in atomic technology laboratory. The structures which are made of Sarooj material need more research to study their resistance against sewage exposure, nitrates, sulfates, mineral salts, humidity, and saturation. Also, it is required to test its long lasting resistance against wind and direct sunray. It is mentioned that the bricks were joined using Sarooj mortar to make brick blocks. Each block element displays a strength and resistance behavior.

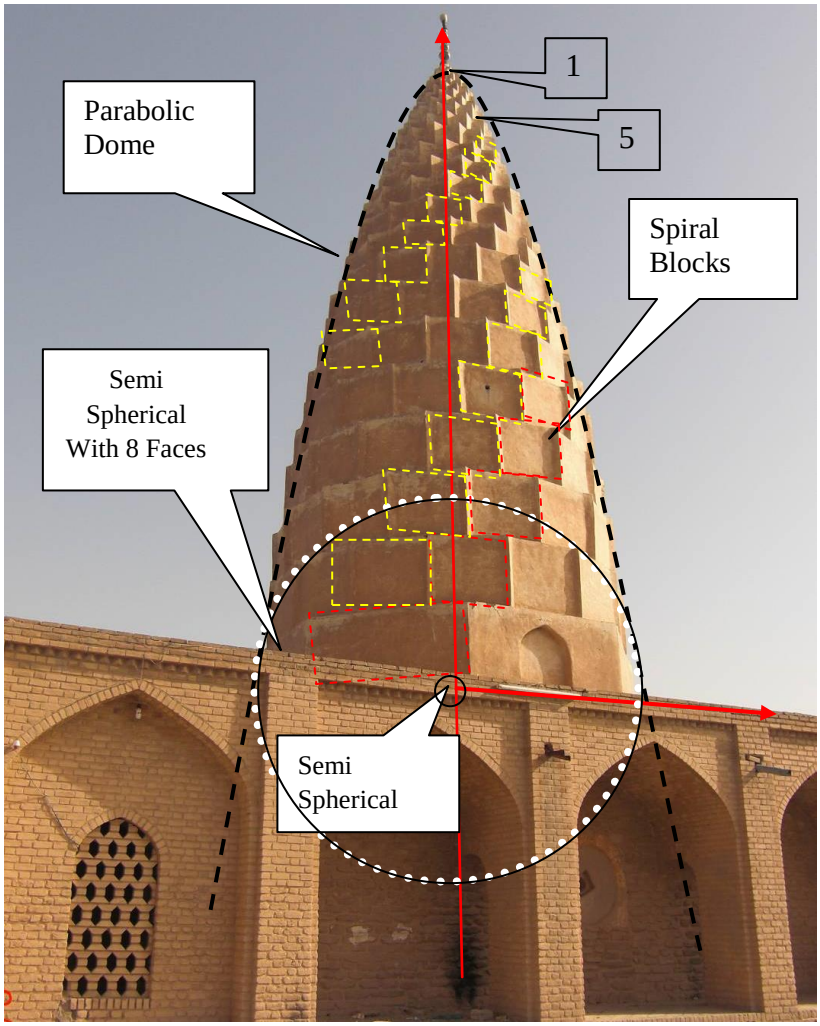

Figure 4. Transit the load of the structure into the walls and the foundation.

Figure 5. The Sarooj mortar elements and aggregations in comparison with the size of a pen.

3 FORMULATION

Figure 6 and Eqs. 1 to 12 explain the behavior of SPD in space. Two-degree equation is demonstrated by h (height) and r (radius) to compute the normal and tangency loads. Each complete spiral block has the same number of face with the same weight and the same radius of block items. For example in block 18, the number of faces is 14 and in the block 5, number of faces is 14 with smaller volume and weight (Voge 1978).

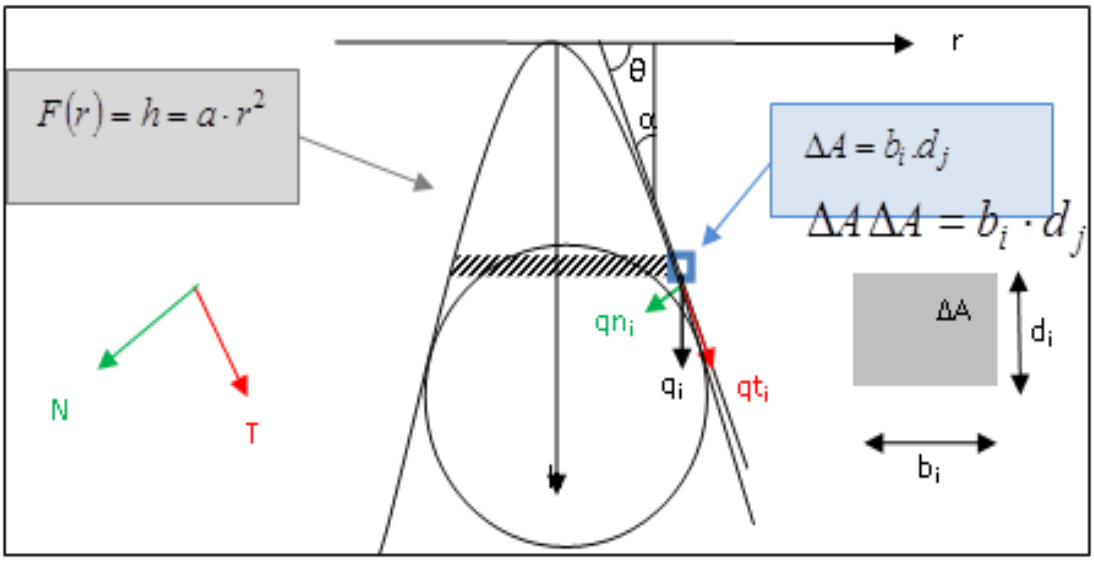

Figure 6. Parabola and normal – tangent plan trajectory.

Eq. 1 is the common shape of parabolic form of curve. Eqs. 2 and 3 are the slope or the first derivative of parabolic Eq. 1. Eqs. 4 and 5 show the volume of spiral bricks in each pitch. Eqs. 6 to 8 represent the tangency loads in T direction of bricks in each spiral pitch. Eq. 9 describes the normal loads in N direction of bricks in each spiral pitch. Eqs. 10 and 11 are the summation of T direction loads of bricks. Also, Eq. 12 refers to the total loads of N direction of bricks.

$$h = ar^2 + br \tag{1}$$

$$dh = (2ar)dr \tag{2}$$

$$tg(\theta) = 2ar \tag{3}$$

$$dv_i = 2\pi\, r_i\, (\Delta A) \tag{4}$$

$$dv_i = 2\pi\, r_i\, (b_i \cdot d_i) \tag{5}$$

$$q_{ti} = q_i \cdot Cos\left(\tfrac{\pi}{2} - \theta_i\right) \tag{6}$$

$$q_{ti} = q_i \cdot Cos\left[\tfrac{\pi}{2} - tg^{-1}(2ar_i)\right] \tag{7}$$

$$q_{ti} = q_i \cdot Sin\ \left[tg^{-1}(2ar_i)\right] \tag{8}$$

$$q_{ni} = q_n \cdot Cos\left(\theta_i\right) = q_n \cdot Cos\left[\, tg^{-1}\left(2ar_i\right)\right] \tag{9}$$

$$\sum_{i=1}^{n}\left(f_t\right)_i = \sum_{i=1}^{n} 2\pi\, r_i\, \left(b_i \cdot d_i\right) \cdot q_i \cdot Sin\left[\, tg^{-1}\left(2ar_i\right)\right] \tag{10}$$

$$\left(F_T\right)_n = \sum_{i=1}^{n}\left(f_t\right)_i = \sum_{i=1}^{n} 2\pi\, r_i\, \left(b_i \cdot d_i\right) \cdot q_i \cdot Sin\left[\, tg^{-1}\left(2ar_i\right)\right] \tag{11}$$

$$\left(F_N\right)_n = \sum_{i=1}^{n}\left(f_N\right)_i = \sum_{i=1}^{n} 2\pi\, r_i\, \left(b_i \cdot d_i\right) \cdot q_i \cdot Cos\left[\, tg^{-1}\left(2ar_i\right)\right] \tag{12}$$

4 CONCLUSION

The dome crown can be increased with minimum energy and maximum resistance against the earthquake and wind vibration load. It is a glory for ancient designers who constructed SPD using local material of bricks and Sarooj mortar. More study is needed to explore the secrets of SPD resistance against wind and earthquakes for more than 600 years.

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