World Academy of Science, Engineering and Technology
International Journal of Aerospace and Mechanical Engineering
Vol:14, No:04, 2020

Determination of Optimal Stress Locations in 2D–9 Noded Element in Finite Element Technique

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Abstract : In Finite Element Technique nodal stresses are calculated through displacement as nodes. In this process, the displacement calculated at nodes is sufficiently good enough but stresses calculated at nodes are not sufficiently accurate. Therefore, the accuracy in the stress computation in FEM models based on the displacement technique is obviously matter of concern for computational time in shape optimization of engineering problems. In the present work same is focused to find out unique points within the element as well as the boundary of the element so, that good accuracy in stress computation can be achieved. Generally, major optimal stress points are located in domain of the element some points have been also located at boundary of the element where stresses are fairly accurate as compared to nodal values. Then, it is subsequently concluded that there is an existence of unique points within the element, where stresses have higher accuracy than other points in the elements. Therefore, it is main aim is to evolve a generalized procedure for the determination of the optimal stress location inside the element as well as at the boundaries of the element and verify the same with results from numerical experimentation. The results of quadratic 9 noded serendipity elements are presented and the location of distinct optimal stress points is determined inside the element, as well as at the boundaries. The theoretical results indicate various optimal stress locations are in local coordinates at origin and at a distance of 0.577 in both directions from origin. Also, at the boundaries optimal stress locations are at the midpoints of the element boundary and the locations are at a distance of 0.577 from the origin in both directions. The above findings were verified through experimentation and findings were authenticated. For numerical experimentation five engineering problems were identified and the numerical results of 9-noded element were compared to those obtained by using the same order of 25-noded quadratic Lagrangian elements, which are considered as standard. Then root mean square errors are plotted with respect to various locations within the elements as well as the boundaries and conclusions were drawn. After numerical verification it is noted that in a 9-noded element, origin and locations at a distance of 0.577 from origin in both directions are the best sampling points for the stresses. It was also noted that stresses calculated within line at boundary enclosed by 0.577 midpoints are also very good and the error found is very less. When sampling points move away from these points, then it causes line zone error to increase rapidly. Thus, it is established that there are unique points at boundary of element where stresses are accurate, which can be utilized in solving various engineering problems and are also useful in shape optimizations.

Keywords : finite elements, Lagrangian, optimal stress location, serendipity
Conference Title : ICCMFMRMSM 2020 : International Conference on Computational Mechanics: Fluid Mechanics, Rock Mechanics and Solid Mechanics
Conference Location : Lisbon, Portugal
Conference Dates : April 16-17, 2020