THE EFFECTS OF FATIGUE ON STEEL STRUCTURES

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ABSTRACT: *Fatigue cracks created under repetitive loads are one of the major threats to the structure of steel structures. Overall monitoring is a common method for detecting fatigue cracks but lacks reliability due to its time consuming. Fatigue phenomena in structures are of crucial importance that must be taken into account. Barrier systems that are widely used in structures include: rigid frames, braced frames, framed tubing. One of the effects these factors may have is structural fatigue. Fatigue is usually associated with germination, cracking at the surface of the stress concentration region or areas of propagation in the stress area. Fracture occurs before the material reaches its ultimate resistance, which is known as fatigue failure. Fatigue failure usually occurs in a crisp and sudden type of failure. The purpose of this study is to investigate the effects of fatigue on steel structures that damage many of the urban infrastructure due to the significant loads being widely applied to the structures, so controlling this phenomenon is very important in the design of structures.*

Keywords: *Fatigue estimation, fatigue life, steel structures, fatigue effects.*

INTRODUCTION

Fatigue is one of the most common failure mechanisms that can be considered as a process of destruction. Fatigue is a process in which permanent structural deformation in the structural members occurs with the creation of cracks, locally and progressively. This phenomenon occurs in most structures, which ultimately leads to breakdown in the structures. The use of components that are pressed to increase the compressive stress near the surface of the cold rolled or shotgun also increases the fatigue life. Also slit or grooved surfaces often reduce the fatigue level of metals.

It has been known since 1850 that the metal under repetitive stress with oscillation will break down at a stress much lower than that required for failure by a single load. Experiments on fatigue-fractured structures show that the fracture begins with a microscopic crack or similar defect. At each loading, the cracks become very small and propagate in the material during successive loading of the material, and as long as the amount of material left unaffected is insufficient for the bearing and a sudden failure occurs. While fatigue failure may start from any cracks or defects, the structural conditions of the structural element have a significant effect on the load endurance obtained.

Fatigue loading

The fatigue phenomenon of metals is more common and is more widely considered. Metal fatigue occurs when the metal is under repeated or oscillatory stress. Therefore, it is necessary to consider the fatigue phenomenon in the design of all structures subject to repetitive loads and oscillatory loads, and it is the task of an engineer to design all the details of a member in order to anchor, cut, and drive force. Applied to that member in each loading iteration shall not exceed the permissible limits of the bylaws and shall not apply any stresses to promote fatigue in the structure.

The number of loading iterations that may occur over the useful life of structural elements is very different. For example, the beam used to support an industrial crane may be loaded two million times during its 25 years of service life (about 300 loads per week), or each blade of a turbine may be several billion times in size. Load your lifetime. [1]

In general, if we want to subdivide fatigue in the structure, it will have 3 main categories including low cycle fatigue, high cycle fatigue, and high cycle fatigue; the figure below shows the number of loads and loads It is said that it is divided into three parts. [2]

Fatigue in structures

Experiments on fatigue-fractured structures indicate that fatigue fractures may begin with any microscopic crack or defect in the material. As each load is applied, the crack will be slightly larger. During successive loads, the crack propagates in the material and expands to the point where some of the material left unharmed is not sufficient to withstand stress and a sudden failure occurs.

So in summary, the fatigue process in the structure is as follows:
3-1- Start leaving

Due to the repeated loads, the small cracks in the piece begin to sprout. The starting point for leaving the body is in areas of discontinuity and places where stress is concentrated.

Growth of cracks
At this point, the cracks grow and continue in a perpendicular direction to the stresses.

Final defeat
At this stage, as the crack growth increases, the stress concentration increases, causing the plastic to deform and break down. [3]

Fatigue failure in structures

Fatigue fracture in structures, even for naturally occurring materials (such as steel and aluminum), is crisp in nature and occurs very quickly without prior warning. [3] It resembles a brittle fracture, perpendicular to the principal tensile stress, with no plastic deformation (residual or residual deformation due to metal flow). [4]

Three major factors are essential for fatigue failure. These include:
- Maximum maximum tensile strength
- Changes sufficiently high or oscillating in the stress of the piece
- High stress cycles applied to the piece

In addition, there are other variables such as stress concentration, corrosion, temperature, overload, metallurgical structure, residual stresses and composite stresses that enhance the conditions for fatigue stress.
Each material has its own stress-strain diagram. To draw the stress-strain diagram, the force is applied (only once) and incremented until the specimen fails at the end of the test. In this case, due to the gradual application of force, there is sufficient time for the strain to expand in the material. The amount of static loads (such as dead and alive loads on building structures) in structures is usually well estimated.

Reducing factors of fatigue effects in structures

Understanding the factors that influence fatigue life can reduce fatigue in structures, but there are some other practical ways to do so.
One of these solutions is to hit the metal surface. The fatigue life of a metal piece can be increased by banging its surface. This causes residual compressive stresses on some surface layers, thereby preventing or delaying the creation of fatigue cracks. Other operations, such as surface hardening or creating some electrical coatings on the surface, cause compressive stresses on the surface layers and, as a result, can cause fatigue in the joint [4] [5].

Fatigue in steel joints

It has already been pointed out that stress-focused areas have high potential for fatigue and are critical points for fatigue crack initiation and eventually failure. One of the most important stress points in steel structures are welds and screw joints. Joints have the task of transmitting stresses from one member to another, and any damage to them is extremely dangerous and confuses the performance and productivity of the structure. Therefore, fatigue analysis in steel joints is of dual importance.
In members that do not have discontinuities such as welding and screws, the process of forming microscopic cracks is slow and it takes a while for the cracks to first form and then grow, but in coils and welds, there are always small and coarse discontinuities and there is actually a cracking stage. It does not exist (small cracks are always present) and therefore, they are less fatigued and tired earlier. [5]
Fatigue failure is the result of a large number of low- to medium-stress loading cycles over a long period of time leading to material breakage and ultimately structural failure.
The loading, which causes fatigue in the element, results in cracking and eventually collapse and failure because the structure is likely to fail before reaching the yield point. That is, while the structure is still in the elastic range, it is still a life threat to residents. The effect of this phenomenon on older buildings can be very significant.
Structural design for strength, plasticity, dynamic response as well as serviceability is the basis of all designs; the common point among all the above is that no analysis of fatigue resistance is performed; however That a structure can be compatible with all the basic principles of structural design, but still suffer severe damage due to fatigue. It should be noted that increased resistance does not necessarily lead to increased fatigue resistance.
For many structural engineers, the subject of fatigue analysis is summarized in several simple controls based on the AISC Steel Structures Guide, which states that no less than 2 million loading cycles are a problem. Therefore, structural engineers

never receive any further training to understand the effects of mechanical fatigue and fracture, except in rare cases, such as the effect of severe earthquakes on bending-frame joint welds [6].

With the increasing importance and also the different applications of structures, we are seeing the development of new buildings, bridges, and infrastructure today with the effects of fatigue taking place, structural engineers have realized that fatigue is more than just a topic in textbooks and has very serious consequences. In the long run considerations are structural. Many structures are over 50 years old, with severe signs of decay and long-term cracking. This phenomenon is especially important in steel and concrete bridges where cracks and caries threaten the safety of this vital artery. Therefore, it is necessary for engineers to try to become more familiar with this phenomenon, to make their designs as well as their decisions with the knowledge of all the relevant points [7].

Cracks caused by fatigue on the surface of metals are often fine-grained and indistinct. Detecting and measuring these types of cracks is one of the important applications of non-destructive tests. One of the non-destructive methods for detecting and measuring the dimensions and shape of these cracks on ferromagnetic metal surfaces is the alternating field measurement method.

Load-resistant systems that are widely used in structures include rigid frames, braced frames, framed tubing. One of the effects these factors may have is structural fatigue. Fracture occurs before the material reaches its ultimate resistance, which is known as fatigue failure. Fatigue failure usually occurs in a crisp manner and is a sudden failure. Therefore, controlling this phenomenon is very important in the design of structures.

From the structural engineer's point of view, ideally designing building system systems only involves choosing how to assemble the core members that are resistant to the combination of multiple loads. Of course, other important non-structural factors may also be involved in determining the type of building structure, such as interior design, materials and methods of construction, architectural aesthetic effects, the nature and amount of horizontal force, height and building ratios. [5]

A review of the past

Fatigue failure of metals has been extensively studied by researchers. The important results of this study were published by Paris et al. They observed that the crack growth rate was largely dependent on the amplitude of the periodic stress intensity factor calculated by the LEFM method [8].

In 2015, several articles presented this article for the safety assessment of fatigue evaluation of welded joints. And then, the likelihood of non-conservative fatigue evaluation is calculated to evaluate different criteria quantitatively. The results of this study provide a re-analysis of the large amount of fatigue test results of welded joints under multilayer loading. S-N has been studied with experimental results for bending, tensile and torsion [1] [6].

The results of a fatigue study performed on a grafted aluminum alloy using epoxy adhesive. This study focused on the propagation of fatigue lesions and included monotonic and fatigue tests using the DCB and ENF tests. Fatigue crack, it has been observed that the growth of mode II fatigue crack requires more energy to crack than the mode fatigue mode I growth, which is consistent with the failed monotonic energies [10] [3].

Rafiei et al. In 2016 considered the life expectancy of composite tubes under internal hydrostatic pressure. Based on the hardness degradation used to evaluate fatigue failure, the progressive damage modeling method was used. The modeling method included three steps: stress analysis The modeling application in predicting fatigue life of composite pipes is confirmed using available experimental data. Finally, the fatigue life of an industrial composite pipe is subjected to various internal pressures. It has been predicted and its long-term behavior during 50 years of continuous operation, as Moore's condition The need is calculated. [9] [11]

Conclusion

High-rise buildings must have sufficient vertical resistance against gravity forces including live loads, dead loads, and lateral forces such as wind and earthquake, etc. One of the effects these factors may have is structural fatigue. Research investigating fatigue behavior in steel structures has been studied. One of the effects that these factors may have is structural fatigue. Therefore, the fatigue phenomenon, including in joints, is of the utmost importance to be considered. The present study shows that the onset of fatigue is an important period in total fatigue. The analysis of steel structures shows that in flange joints, in good locations, the effect of low cycle fatigue is cumulative under severe earthquakes. Since the effects of fatigue are cumulative, this can be significant for older buildings that have experienced multiple earthquakes.

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