

Bracket — Random Vibration Fatigue

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Introduction

In many engineering situations, structural components are subjected to loading that can be considered random. One example is found in consumer electronics, where vibrations exerted onto the circuit boards and similar components are more or less random. Another example is chassis-mounted auxiliary components on a commercial vehicle, where, contrary to engine vibrations, road induced vibrations are more or less random. In order to make a traditional fatigue assessment of components like these, one would need to take a very large time domain sample of the vibration, and perform a time domain fatigue analysis. In most situations, this is impractical. Instead, the statistical information about the vibration is used (typically a PSD spectrum), and fatigue assessments can instead be made using this information. In this example, it is shown how to perform a fatigue analysis of a bracket subjected to random vibration loading.

Model Definition

The bracket geometry can be seen in Figure 1. The random vibration analysis for the bracket uses loading based on a power spectral density (PSD). The computations are based on the modal reduced-order model (ROM). Additional information regarding the model set up, including loading and boundary conditions, can be found in the documentation of the application *Bracket* — *Random Vibration Analysis*, found in the Structural Mechanics Module.



Figure 1: The bracket geometry.

Two cycle counting models are available when performing a random vibration fatigue analysis: the empirical model by Dirlik, and the Bendat (narrow-band) model. In this example, you will use the Dirlik and Bendat models, and pair them with the Basquin fatigue criterion to compute the fatigue life of the bracket. The Basquin fatigue criterion is given by:

$$\sigma_{\rm a} = \sigma_{\rm f}'(2N_{\rm f})^{\rm b} \tag{1}$$

where, in this example, the amplitude stress σ_a is related to the number of cycles N_f through the parameters $\sigma_f' = 2.2$ GPa and b = -0.25.

Results and Discussion

Figure 2 shows the computed fatigue life according to Dirlik's model, and Figure 3 shows the computed fatigue life according to Bendat's model. Both models predict a critical point near a stress concentration, at a fillet. Bendat's model predicts a shorter life (20 h)



than Dirlik's model (24 h). Bendat's model tends to be conservative when the stress response is not narrow-band

Figure 2: Fatigue life according to Dirlik.



Figure 3: Fatigue life according to Bendat.

Application Library path: Fatigue_Module/Random_Vibration/ bracket_fatigue_random_vibration

Modeling Instructions

ROOT

This file serves as starting point for the fatigue computation.

APPLICATION LIBRARIES

- I From the File menu, choose Application Libraries.
- 2 In the Application Libraries window, select Structural Mechanics Module>Tutorials> bracket_random_vibration in the tree.
- 3 Click **Open**.

GLOBAL DEFINITIONS

Parameters 1

- I In the Model Builder window, under Global Definitions click Parameters I.
- 2 In the Settings window for Parameters, locate the Parameters section.

3 In the table, enter the following settings:

Name	Expression	Value	Description
b	-0.25	-0.25	Basquin exponent
sigf	2.2[GPa]	2.2E9 Pa	Basquin strength coefficient

COMPONENT I (COMPI)

From the Home menu, choose Add Physics.

ADD PHYSICS

- I Go to the Add Physics window.
- 2 In the tree, select Structural Mechanics>Fatigue (ftg).
- 3 Click Add to Component I in the window toolbar.
- 4 From the Home menu, choose Add Physics.

FATIGUE (FTG)

Random Vibration 1

- I In the Model Builder window, expand the Component I (compl) node.
- 2 Right-click Component I (compl)>Fatigue (ftg) and choose the boundary evaluation Random Vibration.
- 3 In the Settings window for Random Vibration, locate the Boundary Selection section.
- 4 From the Selection list, choose All boundaries.
- 5 Locate the Moment Computation section. From the Random vibration model list, choose Random Vibration 1.
- 6 From the Physics interface for stresses list, choose Solid Mechanics (solid).
- **7** In the $f_{\rm L}$ text field, type 150.
- **8** In the $f_{\rm U}$ text field, type 800.
- 9 Locate the Fatigue Model Selection section. From the Criterion list, choose Basquin.
- IO Locate the Fatigue Model Parameters section. From the σ_{f}' list, choose User defined. In the associated text field, type sigf.

II From the *b* list, choose **User defined**. In the associated text field, type **b**.

Some parts of the structure are expected to experience infinite life. Use a life cutoff to facilitate the results visualization.

12 In the L_{cut} text field, type 1e3[h].

Random Vibration 2

- I In the Model Builder window, right-click Random Vibration I and choose Duplicate.
- 2 In the Settings window for Random Vibration, locate the Cycle Counting Model section.
- 3 From the list, choose Bendat.

ADD STUDY

- I In the Home toolbar, click $\stackrel{\text{res}}{\longrightarrow}$ Add Study to open the Add Study window.
- 2 Go to the Add Study window.
- 3 Find the Studies subsection. In the Select Study tree, select Preset Studies for Selected Physics Interfaces>Fatigue>Fatigue.
- 4 Click Add Study in the window toolbar.
- 5 In the Home toolbar, click 2 Add Study to close the Add Study window.

STUDY 3

In the **Home** toolbar, click **= Compute**.

RESULTS

Fatigue Life (Dirlik)

- I In the Model Builder window, expand the Results>Fatigue Life (ftg) node, then click Fatigue Life (ftg).
- 2 In the Settings window for 3D Plot Group, type Fatigue Life (Dirlik) in the Label text field.

Surface 1

- I In the Model Builder window, click Surface I.
- In the Settings window for Surface, click Replace Expression in the upper-right corner of the Expression section. From the menu, choose Component I (comp1)>Fatigue>
 Random Vibration 1>ftg.rand1.life Fatigue life s.
- 3 Locate the Expression section. From the Unit list, choose h.

Marker I

I In the Model Builder window, expand the Surface I node, then click Marker I.

- 2 In the Settings window for Marker, locate the Coloring and Style section.
- **3** From the **Background color** list, choose **From theme**.
- 4 From the Anchor point list, choose Lower left.

Fatigue Life (Dirlik)

- I In the Model Builder window, under Results click Fatigue Life (Dirlik).
- 2 In the Fatigue Life (Dirlik) toolbar, click 💿 Plot.

Fatigue Life (Bendat)

- I Right-click Fatigue Life (Dirlik) and choose Duplicate.
- 2 In the Settings window for 3D Plot Group, type Fatigue Life (Bendat) in the Label text field.
- 3 In the Model Builder window, expand the Fatigue Life (Bendat) node.

Surface 1

- I In the Model Builder window, expand the Results>Fatigue Life (Bendat)>Surface I node, then click Surface I.
- 2 In the Settings window for Surface, locate the Expression section.
- 3 In the **Expression** text field, type ftg.rand2.life.
- **4** In the Fatigue Life (Bendat) toolbar, click **O** Plot.