

嵌入式單自由度反應譜程式開發與應用

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摘要

反應譜分析為土木、機械、造船等業界常用的動力分析方法，其步驟是首先利用廣義特徵值分析得到各模態的自然振動頻率，其次透過模態正交化的特性以及給定的單自由度反應譜求得不同模態在特定激振下的最大反應，最後搭配不同的疊加法則來推估待測物的最大反應。然而除卻規範所給定的單自由度反應譜之外，工程師為能夠因應特定外力或振動歷時之單自由度反應譜需求，必須自行建立對應的單自由度系統，重複動力歷時分析才能得到對應的反應譜。為此，本研究利用Python開發可快速產生單自由度反應譜的Abaqus/CAE嵌入式程式。使用者透過該程式之圖形化介面輸入外力或振動歷時，並選擇阻尼形式與輸入阻尼參數。另一方面，嵌入式程式呼叫本研究撰寫之Newmark- β 逐步積分法C++程式模組，計算單自由度系統的反應歷時，進而得到不同自然振動頻率之最大反應，以快速產生對應之單自由度反應譜。此單自由度反應譜可結合Abaqus中的反應譜分析用以探討待測物於特定外力或振動歷時作用下的最大反應。

關鍵字：單自由度反應譜、嵌入式程式、逐步積分、反應譜分析

ABSTRACT

Response spectrum analyses (RSA) are common dynamic analyses for civil, mechanical, and ship-building industries. The procedure of response spectrum analyses starts from the frequency extraction by modal analyses. Next, with the orthogonal characters of vibration modes and the given single-degree-of-freedom (SDOF) response spectrum, one can calculate the maximum response for each mode. Finally, the peak response value of the considered model is obtained according to different modal summation rules. However, except for the pre-specified response spectrum in the design specification, the engineers have to generate the SDOF response spectrum for other external excitations or ground motions before using the RSA to estimate the peak response value. To obtain the SDOF response spectrum for the given external excitations or ground motions, engineers have to create a lot of SDOF models in Abaqus and carry out dynamic transient analyses for these SDOF systems under the external excitations or ground motions. After identify peak transient responses, engineers get the relationships between natural frequencies (or natural period) of SDOF systems and peak responses to plot the response spectrum. In order to overcome the inconvenience, an Abaqus/CAE plug-in program is developed to generate SDOF response spectrum for the given external excitations or ground motions using Python. Users can input the external excitations or ground motions and set the damping parameters (viscous damping ratio or Rayleigh damping) through the user graphic interface (GUI). The dynamic transient analyses for SDOF systems are implemented by the numerical time step integration method (Newmark- β) which is written by C++ code to speed up the efficiency. The plug-in program link the C++ modulus to obtain the peak transient responses over a range of natural frequencies to get the SDOF response spectrum. Finally, users can combine the SDOF response spectrum with the response spectrum analysis in Abaqus to analyse complex systems under any given external excitations or ground motions.

Keywords: single-degree-freedom response spectrum, plugin, time-stepping integration, response spectrum analysis