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阻尼不相似动力学模型的时域响应修正方法

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Updating Method of the Time History Response for Dynamic Similitude Models with Dissimilar Damping Ratios

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摘要 动力学相似的缩比模型试验中,阻尼往往难以保证相似,使得缩比模型的动响应测试数据难以直接换算到结构原型上,因此提出一种阻尼不相似动力学模型的时域响应修正方法来解决这一问题。该修正方法假定缩比模型的阻尼可用比例阻尼模型近似表征,并直接从实际缩比模型与理想缩比模型的一般强迫振动响应计算方程出发,利用线性系统的叠加原理和模态叠加法,将动响应修正量的求解转换为理想模型在一个等效附加激励力作用下的时域响应求解。同时,针对实际工程中响应测点数目有限的问题,利用模态缩聚法进行了未测量点的响应反演。该修正方法仅需已知结构原型和实际缩比模型的模态阻尼比,以及准确建立的实际缩比模型的质量矩阵和刚度矩阵,即可实现实际缩比模型在任意激励工况下的测试动响应修正。以某型飞机的翼梁缩比模型为研究对象,对所提出的响应修正方法进行了验证。试验和计算结果对比分析表明,修正后的响应功率谱密度(PSD)和响应的均方根(RMS)值与理想模型基本一致,表明了本文方法的可行性和有效性。

关键词： 动力学相似   模型试验   阻尼不相似   有限测点   响应修正

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Abstract：During dynamic similitude model experiments, it is generally difficult to assure the same damping ratio of the scaled model with its original structure. As a result, the measured dynamic response of the scaled model with damping errors cannot be used directly to predict the response of the structural prototype. An updating method of the time history response for dynamic similitude models with dissimilar damping ratios is proposed to solve the problem. It is assumed that the damping of the actual and ideal scaled models can be expressed as a classical damping model, and then based on the linear superposition principle and modal superposition method, the updating equations to solve the updating value are deduced from the forced vibration equations of the practical and ideal scaled models. These updating equations show that the calculation of the updating value can be transformed into a dynamic response solution of the ideal scaled model forced by an equivalent additional exciting force. Considering that response measurement points in a practical experiment are usually limited, a reduced order modal method is proposed to reconstruct the responses of those non-measured points. For the proposed updating method, just modal damping ratios, mass and stiffness matrices of the structural prototype and the actual scaled model are needed, and these required conditions are easy to satisfy. Finally, this updating method is used to update the dynamic response of a scaled model of a fighter wing beam structure. The updating results show that the updated displacement power spectrum density (PSD) and root mean square (RMS) values are consistent with real measured responses, which verifies the feasibility and validity of the proposed updating method.

Keywords：dynamic similitude   model experiment   dissimilar damping   limited test points   updating of response

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