

DEVELOPMENT OF COMPUTATIONAL SCHEMES OF GROUP TARGET CONSTRAINTS FOR SOME ELASTIC SYSTEMS PART 1: THEORETICAL FOUNDATIONS

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Abstract: For some elastic systems with a finite number of degrees of freedom of masses, in which the directions of mass movement are parallel, methods have been developed for creating additional constraints, the introduction of each of which purposefully increases the value of only one natural frequency to a given value, while not changing any of the other natural frequencies and not one of the natural modes (forms of natural oscillations). If it is necessary to increase the values of several natural frequencies in a targeted manner, then this requirement can be implemented by creating an appropriate number of separate targeted constraints. The computational scheme of each of the individual targeted constraints should include racks installed at the nodes of mass application and directed along the trajectory of their movement. In some cases, individual targeted constraints can be independently installed on the original (initial) system. In most cases, on the basis of individual targeted constraints, a computational scheme of a united group targeted constraint is developed, which increases all the intended frequencies to the set values, without changing any of the other natural frequencies and not one of the natural modes. The distinctive paper is devoted to a method for forming a matrix of additional stiffness, which corresponds to a group targeted constraint. The requirements for those targeted constraints, on the basis of which a group targeted constraint is formed, are formulated. An algorithm for the development of group targeted constraint is proposed with allowance for the formulated requirements.

Keywords: natural frequency, natural mode, targeted constraint, group targeted constraint,
additional stiffness coefficients

О ФОРМИРОВАНИИ РАСЧЕТНЫХ СХЕМ ГРУППОВЫХ ПРИЦЕЛЬНЫХ СВЯЗЕЙ ДЛЯ НЕКОТОРЫХ УПРУГИХ СИСТЕМ ЧАСТЬ 1: ТЕОРЕТИЧЕСКИЕ ОСНОВЫ ПОДХОДА

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Аннотация: Для некоторых упругих систем с конечным числом степеней свободы масс, у которых направления движения масс параллельны, разработаны методы создания дополнительных связей, введение каждой из которых прицельно увеличивает величину только одной собственной частоты до заданного значения, не изменяет при этом ни одну из остальных собственных частот и не одну из форм собственных колебаний. Если необходимо прицельно увеличить величины нескольких собственных частот, то это требование можно реализовать созданием соответствующего количества отдельных прицельных связей. Расчётная схема каждой из отдельных прицельных связей должна включать стойки, установленные в узлах приложения масс и направленные по траектории их движения. В некоторых случаях отдельные прицельные связи могут автономно устанавливаться на исходной системе. В большинстве случаев на основе отдельных прицельных связей формируется расчётная схема единой групповой прицельной

связи, которая увеличивает все намеченные частоты до заданных значений, не изменяя при этом ни одну из остальных собственных частот и не одну из форм собственных колебаний. В данной статье рассмотрен способ формирования матрицы дополнительных жесткостей, которой соответствует групповая прицельная связь. Сформулированы требования к тем отдельным прицельным связям, на основе которых формируется групповая прицельная связь. Предложен алгоритм формирования групповых прицельных связей с учётом сформулированных требований

Ключевые слова: частота собственных колебаний, форма собственных колебаний, отдельная прицельная связь, групповая прицельная связь, коэффициенты дополнительных жесткостей

INTRODUCTION

In [1-7, 11-15] for elastic systems with a finite number of degrees of freedom [8-10, 16, 17] of masses, in which the directions of mass motion are parallel, theoretical approaches were formulated and methods for development of computational schemes of targeted constraints were proposed. Each of them increases the value of only one natural frequency (frequency of natural oscillations) to a given value, without changing any of the other natural frequencies or any of the natural modes (modes of natural oscillations). If the operating conditions require freeing a certain interval of the spectrum of natural frequencies from several of them, then this requirement can be implemented by creating an appropriate number of individual targeted constraints. Each of these individual targeted constraints includes the main racks, installed in the nodes of mass application and directed along the trajectory of their motion. In some cases, individual targeted constraints can be autonomously installed autonomously on the original system. The distinctive paper is a continuation of [4, 5, 13-15]. It is devoted to a method of development of computational scheme of a united group targeted constraint based on individual targeted constraint, which increases all the intended frequencies to specified values, without changing any of the remaining natural frequencies or any of the natural modes.

Since the development of a group targeted constraint is based on the synthesis of individual targeted constraints, it is necessary to ensure the adequacy of the parameters of each individual targeted constraint with its component in the group targeted constraint.

The rods of the belts of individual targeted constraint retain their independence and parameters in the group targeted constraint. The main racks installed in the nodes of mass application and directed along the trajectory of their movement are combined. In order for the parameters of the main racks of individual targeted constraint to be adequate to their parameters in the group targeted constraint, it is necessary within development of individual targeted constraints, to design the stiffness of the sections of the rods of the racks of these constraints so that they depend only on the number of the rack and do not depend on the numbers of individual targeted constraints.

Let $E[i, k] \cdot F_{st}[i, k]$ be the rigidity of the section of the i -th rack in k -th targeted constraint. Thus, $E[i, k] \cdot F_{st}[i, k]$ should depend only on i and not depend on k .

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The first step.

Individual targeted constraints are developed. Each of them increases one of the intended natural frequencies to a given value. In this case, all actions [4, 5, 13-15] are performed, in which the values of the lengths of all the main racks will be of the same sign. Besides, rigidity of the sections $E[i, k] \cdot F_{st}[i, k]$ should depend only on i and not depend on k .

The second step.

All individual targeted constraints are placed in the nodes of the plate.

The third step.

In areas where several racks are combined, only one is left.

The fourth step.

Hinges are introduced at the intersections of the rods.

When implementing the first step of the algorithm, the frequency spectrum of natural oscillations of the original system with n degrees of freedom

$$\omega[1], \omega[2], \dots, \omega[q], \dots, \\ \omega[q+j], \omega[q+(j+1)], \dots, \omega[n]$$

is considered, in which it is required to specifically free the frequency interval

$$\omega[q], \dots, \omega[q+j]$$

from i frequencies, increasing their values, respectively, to values

$$\omega[s], \dots, \omega[s+j],$$

each of which is greater than $\omega[q+j]$.

When implementing the second step of the algorithm individual targeted constraints are placed in the nodes of the plate. In this case, on the lower sections of the constraint, the racks are combined and, of these, on each of these sections, only one is left.

Within developments of individual targeted constraints, the stiffnesses of the sections of the rods of the racks were set so that they would coincide with each other in each node. It is this circumstance that ensures the adequacy of the parameters of the main racks of individual targeted constraints to their parameters in the group constraint.

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