Rigid Elements

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# Multipoint Constraints

Multipoint constraints constrain some degrees of freedom (DOF) to be equal to linear combinations of the values of other DOF. In the most general form, multipoint constraints can be defined explicitly by directly providing the coefficients of the constraint equations. Rigid elements are a special case of multipoint constraints in which the user provides connection data and the program internally generates the required coefficients.

The global constraint equations can be expressed in the form

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

where is the global[[1]](#footnote-1) displacement vector and is the constraint coefficient matrix. The vector is partitioned into independent and dependent sets

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

where is the dependent set and is the independent set. The matrix of constraint coefficients is similarly partitioned

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

resulting in the following relationship

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

is a nonsingular square matrix, so the constraint matrix can written as

|  |  |  |
| --- | --- | --- |
|  |  | (5) |

and the dependent set values are determined directly from the independent set values through the constraint matrix

|  |  |  |
| --- | --- | --- |
|  |  | (6) |

Details on how the constraint matrix is used to partition the finite element system matrices can be found in the *NASTRAN Theoretical Manual* [1]*.*

# RBE2 Element

The RBE2 element creates a perfectly rigid connection in which all dependent DOF are based on six independent DOF at a specified node. The constraint matrix for six dependent DOF at a single node can be calculated directly using rigid-body kinematics

|  |  |  |
| --- | --- | --- |
|  |  | (7) |

where is the identity matrix, is a zero matrix, is a skew-symmetric matrix assembled based on the distance vector to the dependent node from the independent node (expressed in the dependent-node displacement reference frame), and is a matrix that transforms DOF expressed in the independent-node displacement reference frame to the dependent-node displacement reference frame. The relationship of Equation (7) assumes small angles in .

If the solution algorithm requires constraint coefficient matrices, they can be written as

|  |  |  |
| --- | --- | --- |
|  |  | (8) |
|  |  | (9) |

The signs of the constraint coefficient matrices can be flipped while still remaining consistent with Equation (7).

If more than one node with dependent DOF is specified on an RBE2 element, the relationship of Equation (7) is formed separately for each node with dependent DOF. If the dependent set includes less than six DOF per node, than only the rows corresponding to dependent DOF are retained in Equation (7). Terms in Equation (8) and Equation (9) are updated accordantly.

# RBE3 Element

# References

1. Richard H. MacNeal and others. *The NASTRAN Theoretical Manual*. NASA SP-221(06). Scientific and Technical Information Office, National Aeronautics and Space Administration, 1981.

1. This document uses Nastran terminology and notation. In this context, the global DOF include all structural DOF; these DOF are expressed in their nodal-displacement reference frames. [↑](#footnote-ref-1)