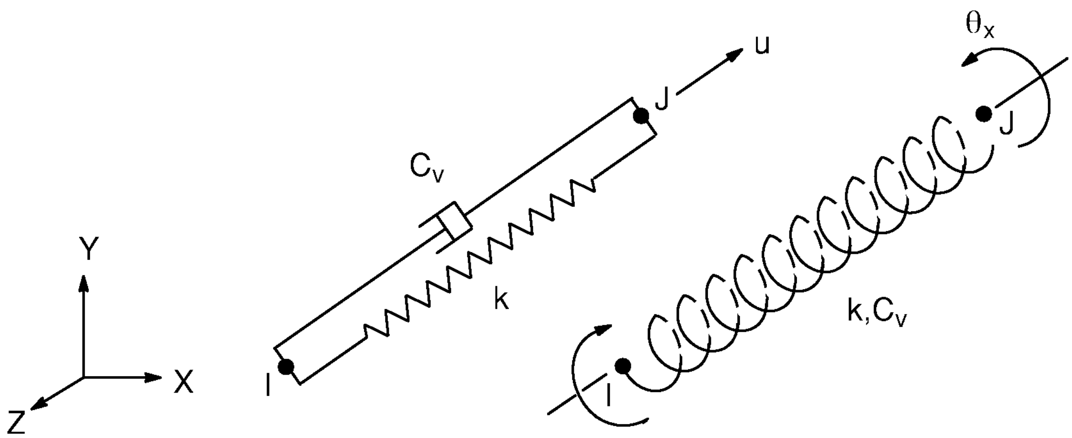
14.14 COMBIN14 — Spring–Damper



Matrix Or Vector	Option	Shape* Functions	Integration Points
Stiffness Matrix	Longitudinal	Equation (12.2.1–1)	None
	Torsional	Equation (12.2.2–4)	None
Damping Matrix	Longitudinal	Equation (12.2.1–1)	None
	Torsional	Equation (12.2.2–4)	None
Stress Stiffening Matrix	Longitudinal	Equations (12.2.1–2) and (12.2.1–3)	None

* There are no shape functions used if the element is input on a one DOF per node basis (KEYOPT(2) > 0) as the nodes may be coincident.

14.14.1 Types of Input

COMBIN14 essentially offers two types of elements, selected with KEYOPT(2).

1. Single DOF per node (KEYOPT(2) > 0). The orientation is defined with the **KEYOPT** command and the two nodes are usually coincident.
2. Multiple DOFs per node (KEYOPT(2) = 0). The orientation is defined by the location of the two nodes; therefore, the two nodes must not be coincident.

14.14.2 Stiffness Pass

Consider the case of a single DOF per node first. The orientation is selected with KEYOPT(2). If KEYOPT(2) = 7 (pressure) or = 8 (temperature), the concept of orientation does not apply. The form of the element stiffness and damping matrices are:

$$[K_e] = k \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \quad (14.14\text{–}1)$$

$$[C_e] = C_v \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \quad (14.14\text{–}2)$$

where:
- k = input as K on **R** command
- C_v = $C_{v1} + C_{v2} |v|$
- C_{v1} = constant damping coefficient (input as CV1 on **R** command)
- C_{v2} = linear damping coefficient (input as CV2 on **R** command)
- v = relative velocity between nodes computed from the nodal Newmark velocities

Next, consider the case of multiple DOFs per node. Only the case with three DOFs per node will be discussed, as the case with two DOFs per node is simply a subset. The stiffness, damping, and stress stiffness matrices in element coordinates are developed as:

$$[K_\ell] = k \begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (14.14\text{–}3)$$

$$[C_\ell] = C_v \begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (14.14\text{–}4)$$

$$[S_\ell] = \frac{F}{L}\begin{bmatrix} 1 & 0 & 0 & -1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ -1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \quad (14.14\text{–}5)$$

where subscript ℓ refers to element coordinates.

and where: F = force in element from previous iteration

L = distance between the two nodes

There are some special notes that apply to the torsion case (KEYOPT(3) = 1):

1. Rotations are simply treated as a vector quantity. No other effects (including displacements) are implied.
2. In a large rotation problem (**NLGEOM**,ON), the coordinates do not get updated, as the nodes only rotate. (They may translate on other elements, but this does not affect COMBIN14 with KEYOPT(3) = 1). Therefore, there are no large rotation effects.
3. Similarly, as there is no axial force computed, no stress stiffness matrix is computed.

14.14.3 Output Quantities

The stretch is computed as:

$$\epsilon_o = \begin{cases} \frac{A}{L} & \text{if KEYOPT(2) = 0} \\ u'_J - u'_I & \text{if KEYOPT(2) = 1} \\ v'_J - v'_I & \text{if KEYOPT(2) = 2} \\ w'_J - w'_I & \text{if KEYOPT(2) = 3} \\ \theta'_{xJ} - \theta'_{xI} & \text{if KEYOPT(2) = 4} \\ \theta'_{yJ} - \theta'_{yI} & \text{if KEYOPT(2) = 5} \\ \theta'_{zJ} - \theta'_{zI} & \text{if KEYOPT(2) = 6} \\ P_J - P_I & \text{if KEYOPT(2) = 7} \\ T_J - T_I & \text{if KEYOPT(2) = 8} \end{cases} \quad (14.14\text{–}6)$$

where: ε_o = output quantity STRETCH

A = $(X_J - X_I)(u_J - u_I) + (Y_J - Y_I)(v_J - v_I) + (Z_J - Z_I)(w_J - w_I)$

X, Y, Z	=	coordinates in global Cartesian coordinates
u, v, w	=	displacements in global Cartesian coordinates
u′, v′, w′	=	displacements in nodal Cartesian coordinates (UX, UY, UZ)
θ_x', θ_y', θ_z'	=	rotations in nodal Cartesian coordinates (ROTX, ROTY, ROTZ)
P	=	pressure (PRES)
T	=	temperatures (TEMP)

If KEYOPT(3) = 1 (torsion), the expression for A has rotation instead of translations, and ε_o = output quantity TWIST. Next, the static force (or torque) is computed:

$$F_s = K \epsilon_o \qquad (14.14\text{–}7)$$

where:

F_s	=	output quantity FORC (TORQ if KEYOPT(3) = 1)
K	=	input quantity K

Finally, if a nonlinear transient dynamic (**ANTYPE**,TRANS, with **TIMINT**,ON) analysis is performed, a damping force is computed:

$$F_D = C_v V \qquad (14.14\text{–}8)$$

where:

F_D	=	output quantity DAMPING FORCE (DAMPING TORQUE if KEYOPT(3) = 1)
V	=	relative velocity

The relative velocity is computed using equation (14.14–6), where the nodal displacements u, v, w, etc. are replaced with the nodal Newmark velocities $\dot{u}$, $\dot{v}$, $\dot{w}$, etc.