CLAIMS

~~1. A method of designing a column-beam joint comprising a concrete column, a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state, and a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, the method comprising:~~

~~defining rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint as a rotational rigidity S_j;~~

~~calculating a required moment resistance, acting on the column-beam joint from the steel beam, using a load supported by the steel beam and the rotational rigidity S_j; and~~

~~adjusting at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam, such that the required moment resistance calculated does not exceed a maximum moment resistance that can be resisted by the column-beam joint.~~

~~2~~1. A method of designing a column-beam joint comprising a concrete column, a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state, and a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, the method comprising:

defining rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint as a rotational rigidity S_j; and

calculating a required moment resistance, acting on the column-beam joint from the steel beam, using a load supported by the steel beam and the rotational rigidity S_j, which is determined by the following process A.

<Process A>

A total number of the resistance elements is denoted by n, i is a given natural number from 1 to n, and the resistance elements are denoted as resistance element i,

the reaction force of the resistance element i is represented by a product of rigidity k_i of the resistance element i and a deformation amount,

a rotation center of the portion of the steel beam inside the concrete of the column is denoted by a point at which the reaction force of the resistance element i and an external force

are balanced,

a distance between a line of action of a representative displacement of the resistance element i and the rotation center is denoted by $x_{d,i}$,

a distance between a center of gravity of the reaction force of the resistance element i and the rotation center is denoted by $x_{l,i}$, and

the rotational rigidity S_j is determined based on evaluation of a value obtained by the following Formula 1.

[Expression 1]

$$S_j = \sum_i (k_i \cdot x_{d,i} \cdot x_{l,i}) \qquad \text{Formula 1}$$

~~3~~2. The method of designing a column-beam joint according to claim ~~2~~1, further comprising

adjusting at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam, such that the required moment resistance does not exceed a maximum moment resistance that can be resisted by the column-beam joint.

~~4~~3. The method of designing a column-beam joint according to ~~claim 1 or~~ claim ~~3~~2, wherein

the resistance element includes an additional member provided at the portion of the steel beam inside the concrete and at a peripheral edge of the portion, and

the required moment resistance or the maximum moment resistance of the column-beam joint is established by adjusting at least one of an arrangement, shape, or dimension of the additional member.

~~5~~4. The method of designing a column-beam joint according to claim 2 or claim 3~~any one of claims 1, 3 and 4~~, wherein

a maximum reaction force borne by a resistance element i of the portion of the steel beam inside the concrete is denoted by $F_{i,Rd}$,

the maximum moment resistance of the column-beam joint is denoted by $M_{j,Rd}$,

a distance between a rotation center of the steel beam and a line of action of the

reaction force is denoted by $x_{u,i}$, and

a minimum value of $M_{j,Rd}$ calculated using the following Formula 2 is established as the maximum moment resistance with a position of the rotation center as a variable.

[Expression 2]

$$M_{j,Rd} = \sum_{i} F_{i,Rd} \cdot x_{u,i} \qquad \text{Formula 2}$$

5. A method of designing a column-beam joint comprising a concrete column, a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state, and a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, the method comprising:

defining rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint as a rotational rigidity S_j;

calculating a required moment resistance, acting on the column-beam joint from the steel beam, using a load supported by the steel beam and the rotational rigidity S_j;

adjusting at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam, such that the required moment resistance calculated does not exceed a maximum moment resistance that can be resisted by the column-beam joint; and

a maximum reaction force borne by a resistance element i of the portion of the steel beam inside the concrete is denoted by $F_{i,Rd}$,

the maximum moment resistance of the column-beam joint is denoted by $M_{j,Rd}$,

a distance between a rotation center of the steel beam and a line of action of the reaction force is denoted by $x_{u,i}$, and

a minimum value of $M_{j,Rd}$ calculated using the following Formula 2 is established as the maximum moment resistance with a position of the rotation center as a variable.

[Expression 3]

$$M_{j,Rd} = \sum_i F_{i,Rd} \cdot x_{u,i}$$ Formula 2

6. The method of designing a column-beam joint according to claim 5, wherein the resistance element includes an additional member provided at the portion of the steel beam inside the concrete and at a peripheral edge of the portion, and

the required moment resistance or the maximum moment resistance of the column-beam joint is established by adjusting at least one of an arrangement, shape, or dimension of the additional member.

~~6~~7. The method of designing a column-beam joint according to any one of claims 1 to ~~5~~6, wherein

an embedded length ratio obtained by dividing an embedded length of the end of the steel beam in the concrete of the column by a beam depth of the steel beam is 0.6 or less.

~~7~~8. A method of manufacturing a column-beam joint, the method comprising

embedding at least one end in a longitudinal direction of a steel beam inside concrete of a column in a semi-rigid joint state, in a state in which a resistance element designed using the method of designing a column-beam joint according to any one of claims 1 to ~~6~~ 7 is provided.

~~8~~9. A column-beam joint structure comprising:

a concrete column;

a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state; and

a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, wherein

when rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint is defined as a rotational rigidity S_j and a moment generated by a maximum resistance that can be resisted by the resistance element is defined as a maximum moment resistance that can be resisted by the column-beam joint, and

by satisfying that an embedded length ratio obtained by dividing an embedded length of the end of the steel beam in the concrete of the column by a beam depth of the steel beam is:

more than 0.4 and less than 0.5 in a case in which the beam depth of the steel beam is 500 mm or less,

more than 0.33 and less than 0.5 in a case in which the beam depth of the steel beam is more than 500 mm and 600 mm or less,

0.14 or more and less than 0.5 in a case in which the beam depth of the steel beam is more than 600 mm and 700 mm or less, and

0.13 or more and less than 0.94 in a case in which the beam depth of the steel beam is more than 700 mm,

as a required moment resistance acting on the column-beam joint from the steel beam, at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam is adjusted, such that the required moment resistance calculated using a load supported by the steel beam and the rotational rigidity S_j does not exceed the maximum moment resistance.

10. A column-beam joint structure comprising:

a concrete column;

a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state; and

a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, wherein

the resistance element includes an additional member provided at the portion of the steel beam inside the concrete and at a peripheral edge of the portion,

the additional member element includes a stud in the column and a face bearing plate,

when rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint is defined as a rotational rigidity S_j and a moment generated by a maximum resistance that can be resisted by the resistance element is defined as a maximum moment resistance that can be resisted by the column-beam joint, and

by satisfying that an embedded length ratio obtained by dividing an embedded length

of the end of the steel beam in the concrete of the column by a beam depth of the steel beam is:

more than 0.4 and less than 0.5 in a case in which the beam depth of the steel beam is 500 mm or less,

more than 0.25 and less than 0.5 in a case in which the beam depth of the steel beam is more than 500 mm and 600 mm or less,

more than 0.21 and less than 0.5 in a case in which the beam depth of the steel beam is more than 600 mm and 700 mm or less, and

0.13 or more and less than 0.94 in a case in which the beam depth of the steel beam is more than 700 mm,

as a required moment resistance acting on the column-beam joint from the steel beam, at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam is adjusted, such that the required moment resistance calculated using a load supported by the steel beam and the rotational rigidity S_j does not exceed the maximum moment resistance.

~~9. A column-beam joint structure comprising:~~

~~a concrete column;~~

~~a steel beam in which at least one end in a longitudinal direction is embedded inside concrete of the column in a semi-rigid joint state; and~~

~~a resistance element that is provided in the steel beam and that generates a reaction force against rotation of the steel beam, wherein~~

~~when rotational resistance per unit rotation angle of a portion of the steel beam inside the concrete in the column-beam joint is defined as a rotational rigidity S_j, as a required moment resistance acting on the column-beam joint from the steel beam, the required moment resistance is set using a load supported by the steel beam and the rotational rigidity S_j, which is determined by the following process B.~~

~~<Process B>~~

~~A total number of the resistance elements is denoted by n, i is a given natural number from 1 to n, and the resistance elements are denoted as resistance element i,~~

~~the reaction force of the resistance element i is represented by a product of rigidity k_i of the resistance element i and a deformation amount,~~

a rotation center of the portion of the steel beam inside the concrete of the column is denoted by a point at which the reaction force of the resistance element i and an external force are balanced,

a distance between a line of action of a representative displacement of the resistance element i and the rotation center is denoted by $x_{d,i}$,

a distance between a center of gravity of the reaction force of the resistance element i and the rotation center is denoted by $x_{l,i}$, and

the rotational rigidity S_j is determined as a value satisfying the following Formula 3. [Expression 3]

$$S_j = \sum_i (k_i \cdot x_{d,i} \cdot x_{l,i}) \quad \text{Formula 3}$$

10. The column-beam joint structure according to claim 9, wherein

at least one of a distance between respective ends of the steel beam or a cross-sectional shape of the steel beam is adjusted, such that the required moment resistance does not exceed a maximum moment resistance that can be resisted by the column-beam joint.

11. The column-beam joint structure according to claim 8 or 10, wherein

the resistance element includes an additional member provided at the portion of the steel beam inside the concrete and at a peripheral edge of the portion, and

the required moment resistance or the maximum moment resistance of the column-beam joint is established by adjusting at least one of an arrangement, shape, or dimension of the additional member.

12. The column-beam joint structure according to any one of claims 8, 10 and 11, wherein

a maximum reaction force borne by a resistance element i of the portion of the steel beam inside the concrete is denoted by $F_{i,Rd}$,

the maximum moment resistance of the column-beam joint is denoted by $M_{j,Rd}$,

a distance between a rotation center of the steel beam and a line of action of the reaction force is denoted by $x_{u,i}$, and

a minimum value of $M_{j,Rd}$ calculated using the following Formula 4 is established as

the maximum moment resistance with a position of the rotation center as a variable. [Expression 4]

$$M_{j,Rd} = \sum_{i} F_{i,Rd} \cdot x_{u,i} \qquad \text{Formula 4}$$

13. The column beam joint structure according to any one of claims 8 to 12, wherein

an embedded length ratio obtained by dividing an embedded length of the end of the steel beam in the concrete of the column by a beam depth of the steel beam is 0.6 or less.