# Selective integration method based on B_BAR technology to calculate the stiffness matrix of C3D8 unit (Python version)

Yimumu jingle bell | 7 months ago | View 7224


The content shared this time is **to calculate the stiffness matrix of the C3D8 unit using the selective integration method based on B_BAR technology** .

## Preface

In the past self-compiled finite element program, I programmed and solved it according to the C3D8 unit stiffness matrix calculation formula in the textbook. The final displacement field result was almost the same as that of Abaqus, but only the stiffness matrix was very different. Check it repeatedly , to confirm the correctness of the program, but the stiffness matrix was different. I was confused at the time, but later found the root cause on the official website of Abaqus. The official explanation is as follows:

Basically, what are the benefits of using the selectively reduced-integration technique?

1. prevent mesh locking
2. provides accurate solutions in incompressible or nearly incompressible cases

Which step was performed in the middle: the strain-displacement relation (B-matrix) is modified.

OK, after knowing the above reasons, I followed the clues, looked up the literature, and found out what it is: **the selectively reduced-integration technique** , and finally found the relevant introduction in Mr. Hughes's book:

There is also a document on the Internet introducing BBAR technology:

Mumu gave you a summary based on the above literature. Again, **you don't need to know the calculation principle clearly, it will be implemented in the program** .

## BBAR theory

For the C3D8 unit, the original strain relationship matrix B should be like this:

$$B = [B_{n_1}, \quad B_{n_2}, \quad \dots \quad , \quad B_{n_8}]$$

For the B matrix of a certain node:

Now transform the matrix:$B$

$$B = B_{dil} + B_{dev}$$

in,

$$B_{dev} = B - B_{dil}$$

OK, that's it for the introduction. If you are interested in the subsequent exciting theoretical content, you can check Mr. Hughes's book in detail. For the program to calculate the unit stiffness matrix, you only need the above formula.

During the integration point cycle, use full integration calculation and reduced integration calculation, that is, 8 Gaussian integration point cycles are performed for , and 1 Gaussian integration point calculation is performed for $B_{dev}B^{tel}B_{dev}B^{tel}$

## python program

```
def calElemStiff2(XCoords, nu):
    """
    基于B_BAR技术的选择性积分法计算C3D8单元的刚度矩阵
    """
    GaussPoints = np.array([[-1, -1, 1],
                            [1, -1, 1],
                            [1, 1, 1],
                            [-1, 1, 1],
                            [-1, -1, -1],
                            [1, -1, -1],
                            [1, 1, -1],
                            [-1, 1, -1]])
    GaussPoints = 1.0 / np.sqrt(3) * GaussPoints
    Ke = np.zeros([24, 24], dtype=float)
    CC = C0(nu)
    for i in range(8):
        # the deviatoric part of B 进行全积分计算
        xi, eta, zeta = GaussPoints[i]
        B_Dev, detJ = BMechDev(XCoords, xi, eta, zeta)
        Ke += np.dot(np.dot(B_Dev.T, CC), B_Dev) * detJ
    # the dilatational part of B 进行减缩积分计算
    xi, eta, zeta = 0.0, 0.0, 0.0
    w1 = 8.0
    B_Dil, detJ = BMechDil(XCoords, xi, eta, zeta)
    Ke += w1 * np.dot(np.dot(B_Dil.T, CC), B_Dil) * detJ
    return Ke
```

Finally, the maximum difference between the elements in the Abaqus stiffness matrix **is max. difference: 5.828670879282072e-16** , which is almost consistent!

Source: Yimumuxiangdingdang



Abaqus UG python theory


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mako 6 months ago

Blogger, have you watched the video of Mr. Zuo Wenjie from Station B? I want to make B-Bar correction to his matlab code. Can I just modify the unit stiffness matrix function directly?

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