Analytical Study on the Development of Bulb Sleeve Shape for Hybrid Bolts, Considering the Thickness of the Fastening Plate

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Development of Optimal Bulb Sleeve Shape Using Finite Element Analysis

BACKGROUND

The hybrid bolt (**Figure1**) is designed with a bearing mechanism in which the sleeve makes contact with the wall of the bolt hole, allowing for **the combined use of frictional and bearing forces**. The performance of these forces may vary depending on the shape of the formed **Bulb**. Within the **grip range** — defined as the range of plate thicknesses that can be fastened — the **formed Bulb** must exhibit an **appropriate shape** for application to steel structures and ensure **sufficient contact Force** between the joined members.

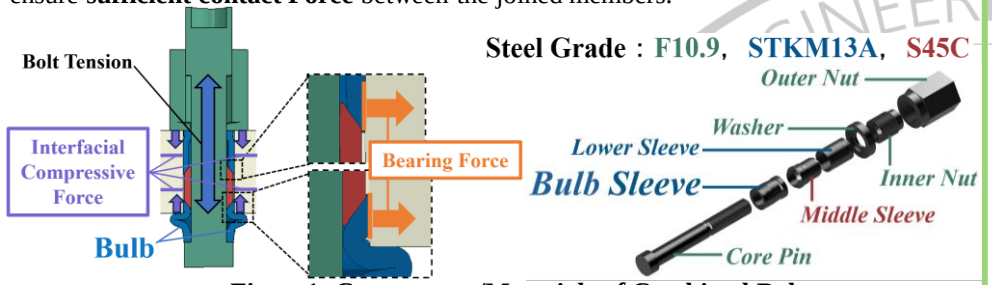

Figure1: Components/Materials of Combined Bolts

METHOD

Analysis solver : Abaqus/Standard 2023
Material properties : Experimental value for Bulb/Lower Sleeve (Multilinear)
: Nominal values for other (Bilinear)
Element size : 0.1 mm to 2.0 mm
Interactions : Coulomb friction (Penalty method)
The coefficient of friction : 0.45 for the joint
0.10 for other

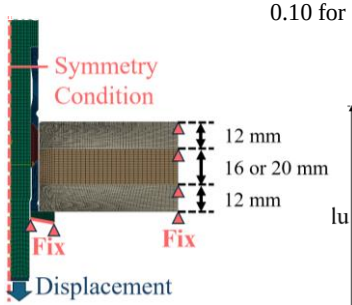

Figure2: Analytical Model

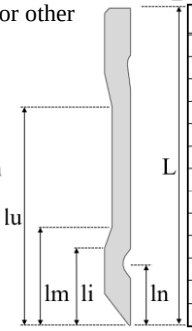

Table 1: Bulb sleeve Geometrical Parameters

Shape	lu (mm)	lm (mm)	ln (mm)	li (mm)	L(mm)
S-1	20.5	11.5	7.2	9	32
M-1	22	12	6	6.5	35.5
L-1	22	9	5	5	37
L-2	24	9	5	6	37
L-3	22	10.5	5.5	6.5	37
L-4	24	11.5	5.5	6.5	37
L-5	22	12	6.5	6.5	37
L-6	22	12	7	6.5	37
L-7	22	14	7.2	9	37
L-8	23	14	7.2	9	37
L-9	24	14	7.2	9	37
L-10	25	14	7.2	9	37
L-11	25.5	11.5	7.2	9	37

The analytical model is an **axisymmetric model** as shown in **Figure2**.
The **Bulb sleeve Geometrical Parameters** is listed in **Table 1**.

KEYWORDS ☐ **Blind bolt, Grip range, Contact Force**

RESULTS

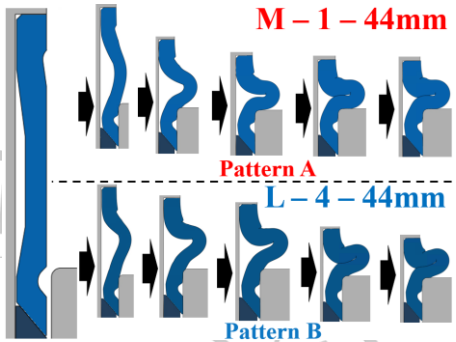

Figure3: Deformation Patterns of Bulb

(1) Formed Bulb shape

From **Figure 3**, the deformation of the bulb sleeve is categorized into two patterns (A and B). **Pattern A involves direct contact** between the bulb and the fastening material, while **Pattern B involves a gap**. In blind bolt configurations, corrosion of the bulb sleeve causes a reduction in bolt axial load. **Pattern B** shows greater exposure to air, implying more significant corrosion effects, making the head unsuitable for this setup.

(2) Interfacial Contact Force

From **Figure 4**, the deformation of the Bulb can **be classified using the ratio *lm*/*lu*=6/11.**

From **Figure 5**, **M-1**, **L-5**, and **L-6** with **small *lm*/*lu*** ratios show **high introduction** of **Interfacial Contact Force** rates for 40 mm and 44 mm plate thicknesses with little variation. **M-1**, achieving **over 80% introduction**, **difference in introduction rate** due to plate thickness is **less than 10%** within the grip range.

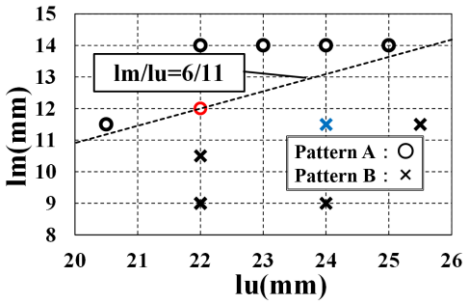

Figure 4: Deformation Patterns and Geometrical Parameters

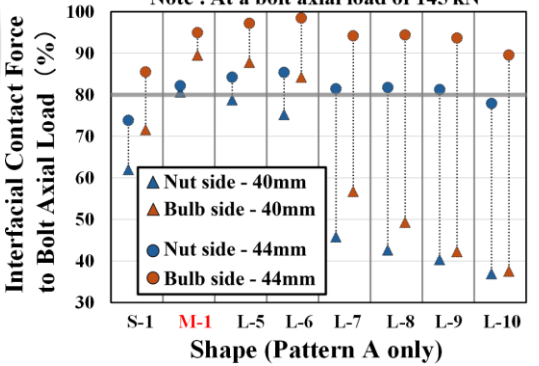

Figure5: Introduction Ratio (Core Pin Axial Force: 145 kN)

SUMMARY

✓ The Bulb sleeve exhibits **appropriate deformation** when the ratio ***lm*/*lu*** **is greater than 6/11.**
✓ The **Optimal Bulb sleeve shape**(**M-1**) has **introduction rate of over 80%**.