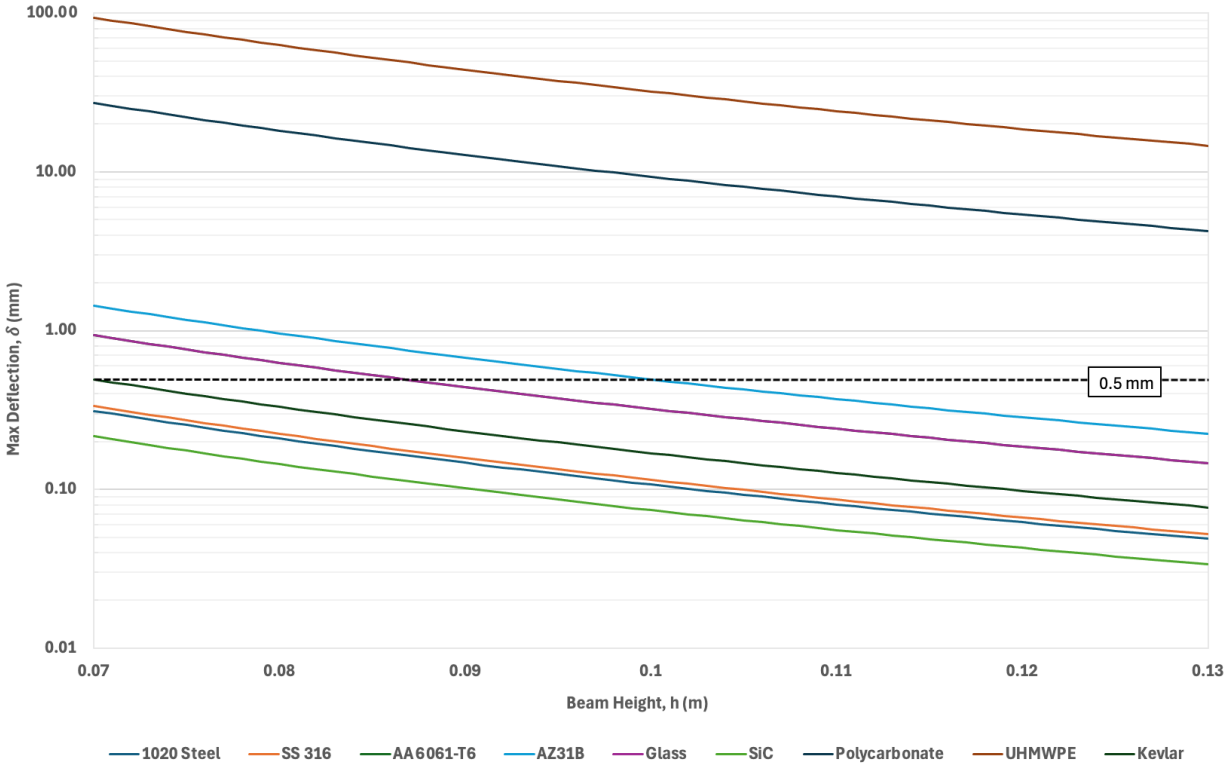


*Figure 1. Comparison of the maximum deflection of a crossbeam of a swing set, modeled as a simply supported beam under a center load, for different materials as a function of beam height. Material data from Callister, 10e, Appendix B.*

The crossbeam on a swing set needs to have a maximum deflection less than 0.5 mm under a 1,000 N force applied at the center of the beam. Figure 1 shows materials that can meet this criterion for beams with a length of 2.07 m, a width of 0.1 m, and heights between 0.07 and 0.13 m. We can determine from the figure that SiC, Kevlar, Stainless Steel 316, Aluminum Alloy 6061-T6, and 1020 Steel meet the specification at any beam height between 0.07 and 0.13 m, while Polycarbonate and UHMWPE never meet the requirement within the specified height range. AZ31B and Glass deflect less than 0.5 mm only at heights greater than 0.1 m and 0.087 m, respectively.

*Table 1. Material Comparison for swing set beam. Data from Appendix B in textbook, except where noted. Material properties are taken at the high end of their range.*

| | Mass (kg) | Cost ($) | Max Deflection (mm) | Corrosion Resistance | Stress to crack (MPa) | Safety Factor |
|---|---|---|---|---|---|---|
| **1020 Steel** [a] | 487.5 | 901.85 | 0.3968 | Good | 2212.31[b] | 10.14[c] |
| **316 Stainless Steel**[d] | 496.8 | 3601.80 | 0.4255 | Good | 2948.67[b] | 5.94[b] |
| **AA6061-T6** | 167.7 | 1291.06 | 1.1903 | Good | 940.72[b] | 8.00 |
| **AZ318 Mg**[e] | 109.9 | 5495.85 | 1.8251 | Poor | 908.28 | 5.80 |
| **Glass**[f] | 155.3 | 1412.78 | 1.1903 | | 24.33 | 2.00[g] |
| **SiC** | 198.7[h] | 39744.00[i] | 0.3968 | | 155.71 | 15.07[e] |
| **Polycarbonate** | 74.5 | 298.08[j] | 34.5072 | | 64.88 | 1.80 |
| **UHMWPE** | 58.4 | 466.99 | 119.0250 | | 129.75[k] | 0.80 |
| **Kevlar FRP** | 86.9[l] | 5651.10 | 0.6269 | | 63.58[m] | 118.84[n] |

[a] Cold rolled
[b] From Matweb
[c] Minimum
[d] Hot finished and annealed
[e] Extruded
[f] Soda-Lime
[g] Flexural Strength
[h] Sintered
[i] $\alpha$-phase
[j] Sheet
[k] From Link
[l] 60% volume fraction
[m] 7% with PMMA, from Link
[n] Tensile Strength

The criteria for a successful material for the cross beam of a swing set are a weight less that 170 kg, a cost less than $1,291, and a maximum deflection below 1.5 mm under a force of 100 kN. It also needs to be resistant to corrosion in seawater with zinc bolts and to cracking from external scratches as large as 0.25 mm, and it needs to not yield. Table 1 presents the results of these criteria, color coded such that green is acceptable, orange is marginal, and red is unacceptable. If the value is within 2% of each specification, it is considered marginally acceptable.

The final recommended swing set cross beam material is Aluminum 6061-T6, because it meets all of the requirements besides the cost requirement, which it only exceeds by 6 cents. The final beam will be 2.07 m long, 0.1 m wide, and between 0.07 and 0.13 m tall. Kevlar would be a good secondary option is the cost requirement were ignored, and1020 Steel would be goods secondary option if the weight requirement was shifted higher as well.