Ceramic Bowl Fracture Analysis

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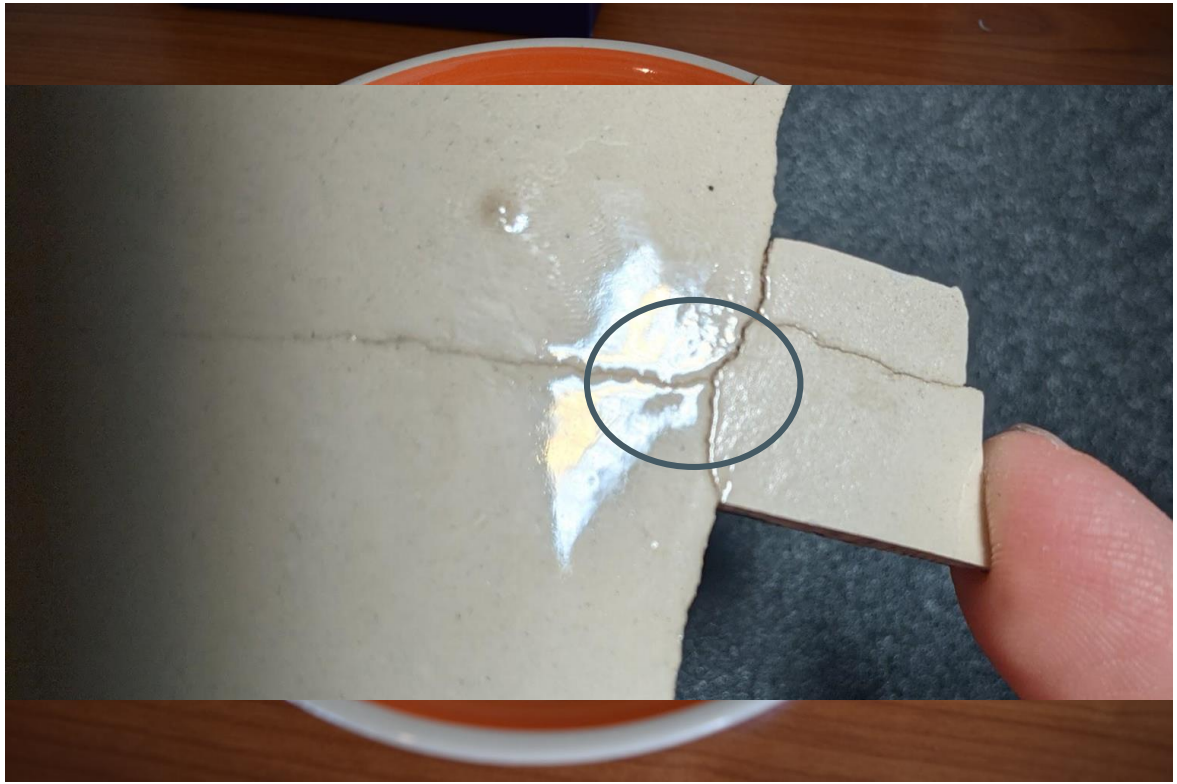
Background

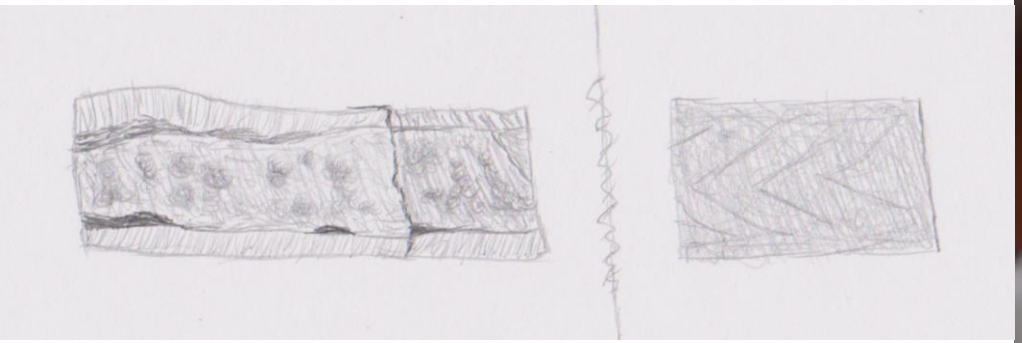
- Cheap ceramic bowl made/bought in mexico
- Used for a couple years
- Microwave safe, dishwasher safe
- Bowl had developed two intersecting cracks
- Roommate wanted to see if he could break the bowl and thus snapped it in half on purpose



Fracture Analysis Investigation

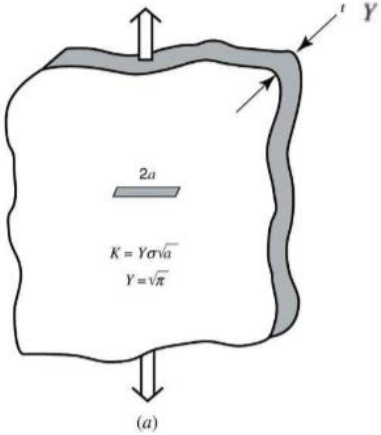
Pencil Sketch:

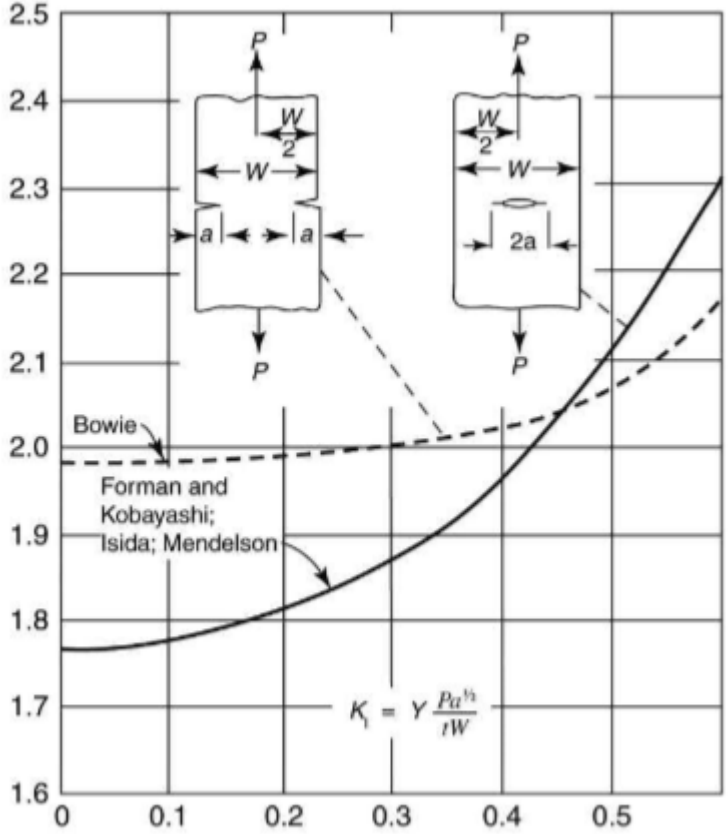
- Left side is the center of the bowl and right side begins roughly 3 inches outwards
- 3 distinct layers transitioning to more uniform layer the farther we get from center
- Feint chevron markings (right sketch only)



Givens/Assumptions

- Cheap hand molded - fired clay
- Assumed *Ceramic Tile* in Granta EduPack
  - Density = 0.0741 lb/in^3
  - Young's Mod = 0.58e6 psi
  - Sy = 0.435 ksi
  - Fracture Toughness = 0.91 ksi*in^0.5
- Crack in center of bowl
  - Figure 6.21(c)
- W = diameter = 7.875 in
- Crack before failure = 2a = 4in

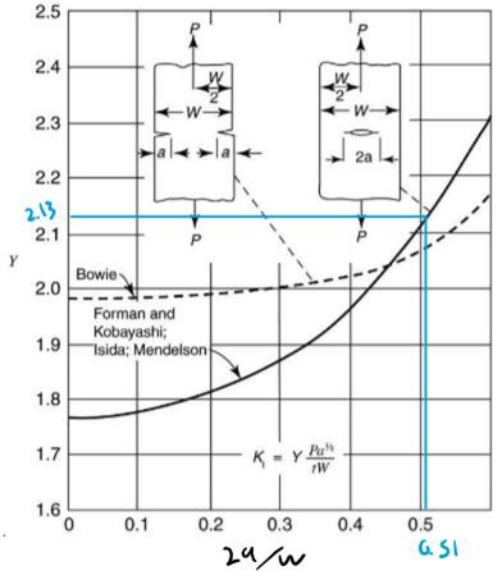




Fracture/Stress Analysis

Mode of failure

1. Thermal stress
2. Crack propagation
3. Overload
4. Fast Fracture (brittle)



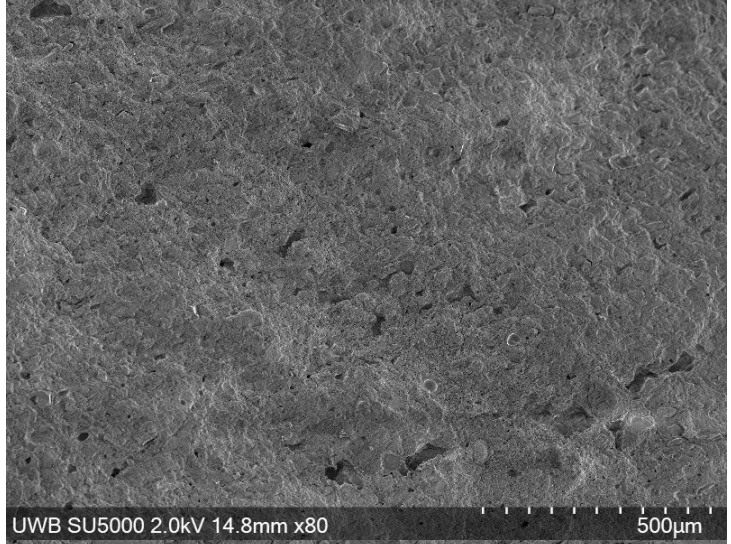
$$\frac{2a}{w} = \frac{4\ in}{7.875\ in} = 0.51$$

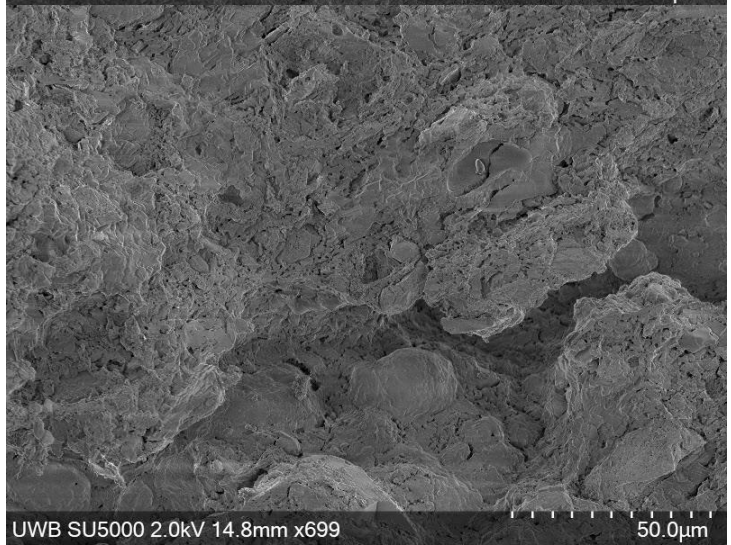
$$K_1 = 0.91\ ksi\sqrt{in} = 2.13 * \frac{P * \sqrt{2\ in}}{0.156\ in * 7.875\ in}$$

$$P = 0.37\ ksi$$

Conclusion

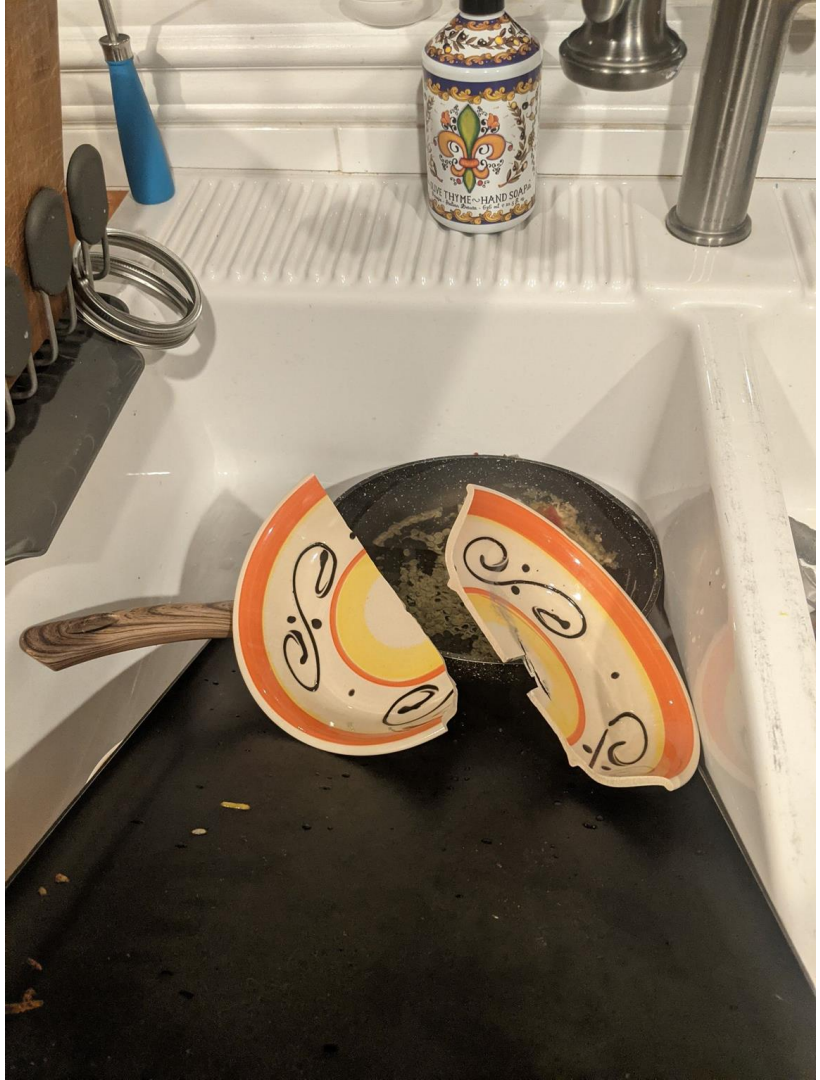
- Porous material
  - Trap water
  - Water heats in microwave
- Thermal expansion stress
- Crack formation -> propagation
- Lowered critical load





Recommendations

- Less porous material reduces thermal expansion
- Stronger material such as zirconia where the fracture toughness is 8 or 9 compared to our 0.91 ksi*in^0.5
- Better sealing
- Wash your dishes



Any Questions?

Citations

Hertzberg, R. W., Vinci, R. P., & Hertzberg, J. L. (2013). Deformation and fracture mechanics of engineering materials. Wiley.