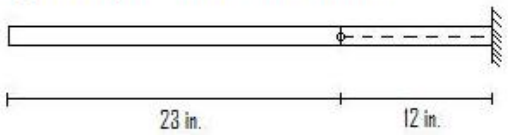
Doors, being an everyday object, are not typically thought of in any spectacular terms. They are used continually and taken for granted, and not without reason. There are only a handful of door designs that a person is likely to use on a given day (such as the typical swinging door with hinges on one edge, or perhaps an automatic sliding door at the supermarket), so it is no surprise that such commonplace objects are rarely the cause of much consternation or glee. However, some doors are designed in a way that makes them more unique and therefore more likely to capture the imagination. One such design that has been talked about in stronger editorial terms than one would expect appears in the front doors to the Northwestern Technological Institute and the Ford Design Center.

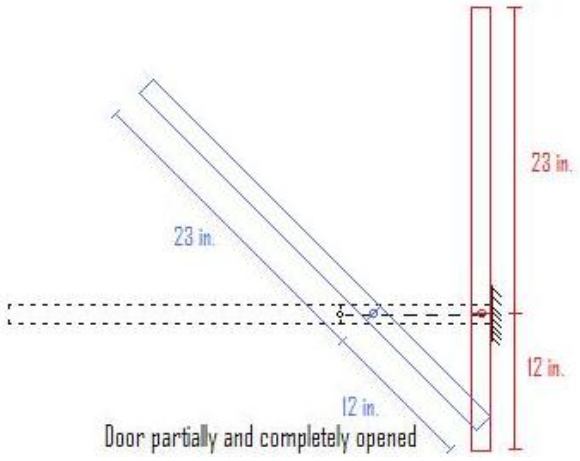
Door Specifications

The doors do not appear remarkable at first glance. The ones that open into Tech are made of brass with glass windows, and the ones at Ford are mostly glass with an outer rim of stainless steel. Ford's doors are 35 inches wide and about 100 inches high. They have a stainless steel bar on one side and handle on the other at a height of 39 inches from the ground. The unique part of the design, however, is an offset moving hinge that, when the door is closed, is 12 inches from the door frame, and when it is open is flush with the door frame. This means that when

Figure 1: Diagram of Door Viewed from Above



Door completely unopened



Door partially and completely opened

the door is opened, one foot of it is sticking on one side of the door frame, while the other 23 inches are on the opposite side of the doorframe (Figure 1). The doors are also noticeably many times heavier than a typical door inside of a house (though an exact weight cannot be determined due to lack of equipment and access to construction details). Precise measurements for the doors to Tech could not be obtained, but are assumed to be similar in proportion to the doors to Ford since they have similar weight and the same hinge system.

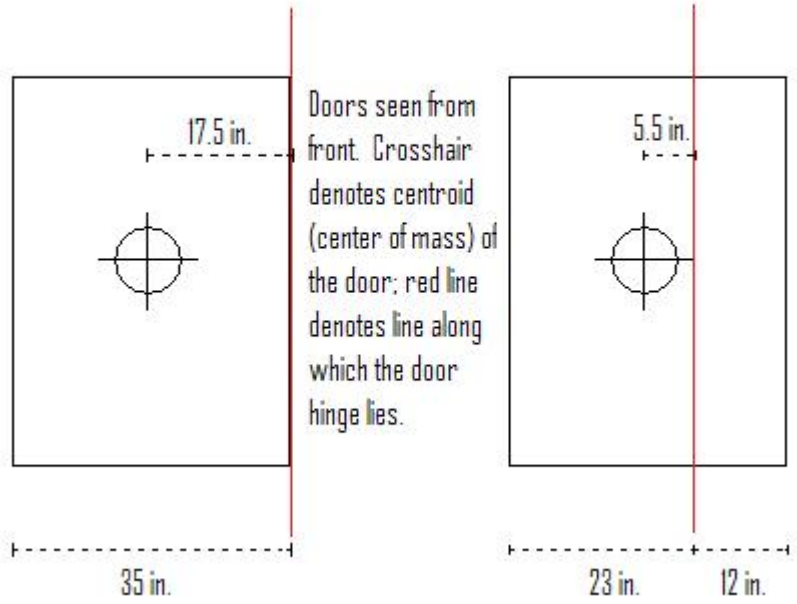
Design Analysis

Perhaps the most remarkable and easily recognizable feature that the doors to the Technological Institute and Ford Design Center bear is their unmistakable physical weight. This quality is neither intrinsically good nor bad; some could argue that the weight of the doors is a tactile component of the aesthetic of the doors. However, the weight of the swinging door is so significant that it has been known to cause inconvenience to all but the largest and strongest of users, and could cause legitimate problems for smaller people or those with limited mobility. One would likely conclude that the doors were most likely designed with their aesthetic appeal in mind above their actual day-to-day practicality. A definitive objective appraisal of this aspect of the design is hard to reach; technically speaking, the doors do meet their most important user needs (being able to get from outdoors to indoors, or vice-versa) and can certainly be considered a successful design in that capacity. However, in terms of ease of use, this part of the design is somewhat less successful. The great weight of the door actually impedes every single user from completing the task for which every door on the planet was built—to allow someone to get from one discrete location to another. The weight of the door partially obstructs the flow of people in

and out of Tech and Ford, and therefore can be considered to be a negative attribute in terms of meeting the physical needs of most users.

Another one of the distinctive features of the doors is the offset hinge. Although this may have some aesthetic appeal (see the user response section below), the position of the door hinge decreases the maximum possible radius over which a force can be applied—this means that a student trying to open the door cannot exert as much torque on the door as they could on a door with similar width but an ordinarily placed hinge. Given the door width of 35 inches and the hinge placement 12 inches away from the doorframe, a person can only create 65.7% of the torque on the doors of Ford as they could using the same amount of force on a door with equal width and a typical hinge (Equation 1). This placement of the hinge therefore makes it yet more difficult to open the doors, which are already uncharacteristically heavy. Another notable effect of having the door hinge offset is that it narrows the width of the open portal, making it more difficult for people carrying many items or those whose maneuverability is hampered by other means to get through the doorway. One positive mechanical aspect of the offset hinge, however, is that by decreasing the distance between the center of mass of the doors and the hinge it decreases the amount of stress the hinge experiences

Figure 2: Center of Mass of Doors



due to the moment created by the weight of the door by 68.6% (Figure 2), which is probably quite important given the massive size of the doors. It can therefore be speculated with reasonable certainty that the reason for the offset hinge is to fulfill the requirements of the builders and engineers of the Ford project in lieu of satisfying user needs (given the previous negative attributes listed). Since the very nature of the design affects its ease of use negatively, it can be considered an overall negative design attribute. However, the design's ineffectiveness is mitigated in part by the superior load-bearing properties of the offset hinge, so it can overall be considered a neutral attribute of the door.

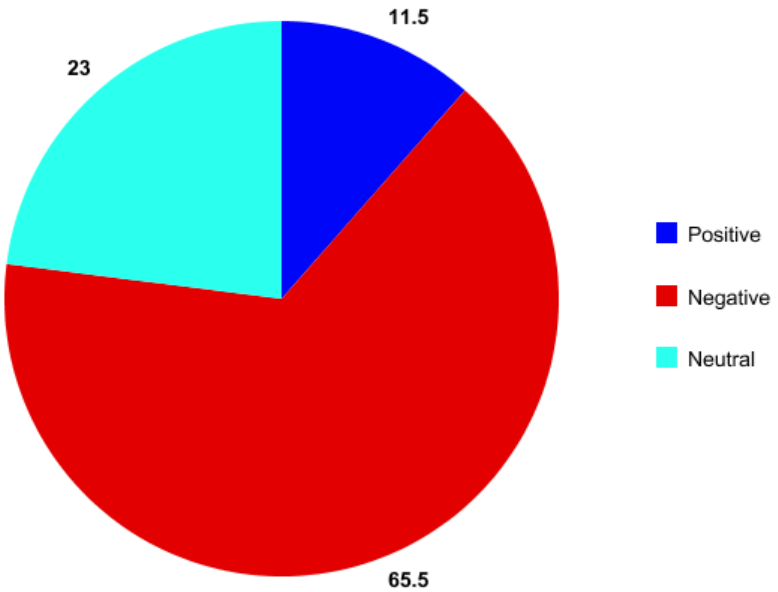
One of the most important features of the doors to the Northwestern Technological Institute—though not of the Ford Design Center, which has doors that can be operated electronically—is perhaps the most overlooked: it is possible to place these doors so that they stay in an open position. When the doors are held at ninety degrees to their frame and pushed into place, they remain open until jostled or disturbed by passersby. This design feature could arguably negate the credibility of the argument that the doors suffer from their heavy weight and unusually designed hinges, as the large moment of inertia produced by the swinging of the door is rendered irrelevant if the door is in fact stationary. This design aspect would theoretically eliminate any cause for complaint about the heftiness of the doors to the engineering buildings, but the fact of the matter is that they are still a common—in fact, practically universal—source of griping among students at Northwestern University (see survey conducted in the user response section). The design was possibly implemented with the idea in mind that students on their way to class would have the patience and presence of mind to take an extra moment and set up the doors so that the rest of the crowd would be able to pass unimpeded, but this is behavior is rarely

observed during the morning rush into the Technological Institute. One reason that could help account for this, other than hurriedness of the student body, is that the doors are all unmarked and display nothing to indicate that they would be capable of staying open on their own. This part of the design succeeds in functionality but fails to be intuitive, and thus was likely not designed with the mindset of the average user in mind—lacking proper markings on the door would not be likely to satisfy any other stakeholders' needs, either, so the only divinable reason for their absence is poor design. Not only that, but having entranceway doors that automatically stay open is impractical and expensive for any building (such as Tech) that is climate-controlled throughout the year.

User Response

One of the most important ways of evaluating a design relies not upon quantitative research of the design itself but upon the opinions of the various stakeholders in the design. This would include the designers of Ford (who unfortunately could not be reached for comment) and of course the door's users. In a survey of 52 students who do or did at some point regularly use the doors to either Tech or Ford, 65.5% had an overall negative response to the design of the doors,

Figure 3: Response of Students to Doors of Tech and Ford



Conducted by Noah Mosberg

while only 11.5% said that, all things considered, they liked the doors. The rest of those surveyed were either neutral or apathetic to the design (Figure 3).

Among those who responded negatively, the overwhelming reason for their sense of displeasure was the heaviness of the doors and how it made them too difficult to open. This is relevant to the design of the hinge because, as previously noted, its placement reduces the amount of torque a person can apply to the hinge. One student noted that smaller or weaker people, not to mention people using crutches or carrying cumbersome packages, frequently encounter problems with the doors (D. W. Kim, personal communication, February 1, 2009). Those who had a positive opinion of the design were influenced chiefly by the aesthetic appeal of the design, with one user calling the unique opening mechanism "classy and unique" in its appeal (J. Rosner, personal communication, February 25, 2009). Another student mentioned that the doors to Ford had an air of modernity and that the heft of the swinging door gives the additional feel of solid construction (K. Stevens, personal communication, February 1, 2009).

Conclusion

Taking into account all of the most important aspects of the door design, it can be concluded that the design as a whole is not well thought out, particularly in terms of user needs. While the design does not outright fail at what it is supposed to do (open, close, and let people pass), its great weight and offset hinge make it much harder to open than seems necessary. Even though the offset hinge can likely bear a heavier load than its ordinary counterpart, making it superior for a heavy door, there is no readily apparent need to make the doors as heavy as they are. It would solve door-opening problems if both the large weight and the offset hinge were removed. Although the capacity for the doors to Tech to stay open is theoretically a good design

consideration, they are rarely kept that way because it is not intuitive to do so. Overall, the design for the doors was poorly thought out and could have been replaced by standard doors without any foreseeable problems arising.

Equation 1: $(35\cos\Theta - 12\cos\Theta)/35\cos\Theta = 23\cos\Theta/35\cos\Theta = 23/35 = .657 = 65.7\%$

The $35\cos\Theta$ denominator refers to the perpendicular distance from the applied force to the hinge of an ordinary 35 inch wide door at any given angle. The $35\cos\Theta - 12\cos\Theta$ on the top refers to the perpendicular distance from the force applied on Ford's entrance doors to the door frame minus the distance from the hinge to the doorframe (which changes based upon the angle at which the door is open). This creates a ratio of one particular radius to another particular radius, which can be extrapolated to a ratio of torque experienced at the door hinge of Ford's doors to torque experienced at the door hinge of an ordinary door.