# Reinventing Gabions: How Collaboration Led to New Methods of Building Laterally Stable Walls

**RICK SOMMERFELD**
University of Colorado Denver

**ANDY PADDOCK**
RMG Engineers

In the memoirs of well-known engineers (consider Informal and Crossover by Cecil Balmond or An Engineer Images by Peter Rice) anecdotal tales of early design conversations dominate the writings. It is in this dialogue where common goals are struck, concepts are realized, and the foundations of the projects emerge.

The question then is not if we collaborate with engineers, but how and when we collaborate with them.

For ColoradoBuildingWorkshop, the design-build program at the University of Colorado Denver, the structural engineer is present at the first client meeting and remains engaged throughout the design process. This early engagement with students is critical to successful project outcomes. To stress the importance of these conversations, and better integrate structural engineering into the curriculum, the department now offers a support course to compliment the design-build studio co-taught by Andy Paddock, PE. This early and consistent collaboration has yielded a series of innovative projects perhaps none more successful than the 2018 project in Rocky Mountain National Park.

The project brief called for four privies along the historic Long's Peak Trailhead. Located at elevations between 10,500 - 12,800 feet above sea level, and as far as five miles from the trailhead, each of the three sites are inaccessible by vehicle. Given the sensitive flora and historical nature of the trail, each privy was required by the National Park Service (NPS) to blend into the surroundings while minimizing the physical impact to the landscape. Additionally, each structure needed to be erected in less than eight days to decrease the exposure each student would face building at such an extreme elevation. To add to the complexity, the NPS asked that each structure be light enough to be lifted by a helicopter but strong enough to sustain winds of more than 225 miles per hour.

The final design solution is a series of prefabricated structural gabion walls. Each of the steel louvers between gabion modules act as a moment frame connected by a continuous ring plate above the walls. The ring plate transfers lateral loads from one leg of the moment frame to a corresponding leg on the opposite wall. This ring plate is key to the structural system, effectively bending and transferring lateral forces around the structure, allowing the moment frames to work along their lines of action. To keep the structure as light as possible the gabion rocks were collected on-site. The rocks act as ballast for the structure and laterally brace each of the 1/8" thick steel plate moment frames to prevent them from laterally buckling. This hybrid structural system allowed the steel plate louvers to be reduced from 1/4" to 1/8" plate and the gabion walls to be reduced from their original 18" thickness down to 12 inches. This minimized onsite construction, cut structure weight by nearly 40%, and reduced onsite rock collection, and therefore the impact to the flora, by 33%.

Architecture, Engineering and the Multiplicity of the Creative Process

# REINVENTING THE GABION:

How Collaboration Led to New Methods of Building Laterally Stable Walls

**Colorado**Building**Workshop**, UNIVERSITY OF COLORADO **DENVER**
Authors: Erik "Rick" Sommerfeld, Assistant Professor
William Koning, Bixler Design-Build Fellow
Andy Paddock, Structural Engineer

In the memoirs of well-known engineers (consider *Informal* and *Crossover* by Cecil Balmond or *An Engineer Images* by Peter Rice) anecdotal tales of early design conversations dominate the writings. It is in this dialogue where common goals are struck, concepts are realized, and the foundations of the projects emerge.

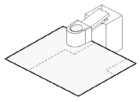
The question then is not *if* we collaborate with engineers, but *how* and *when* we collaborate with them.

For **Colorado**Building**Workshop**, the design-build program at the University of Colorado Denver, the structural engineer is present at the first client meeting and remains engaged throughout the design process. This early engagement with students is critical to successful project outcomes. To stress the importance of these conversations, and better integrate structural engineering into the curriculum, the department now offers a support course to compliment the design-build studio co-taught by the engineer. This early and consistent collaboration has yielded a series of innovative projects perhaps none more successful than the 2018 project in Rocky Mountain National Park.

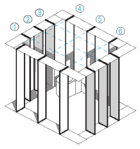


The project brief called for four privies along the historic Long's Peak Trailhead. Located at elevations between 10,500 - 12,800 feet above sea level, and as far as five miles from the trailhead, each of the three sites are inaccessible by vehicle. Given the sensitive flora and historical nature of the trail, each privy was required by the National Park Service (NPS) to blend into the surroundings while minimizing the physical impact to the landscape. Additionally, each structure needed to be erected in less than eight days to decrease the exposure each student would face building at such an extreme elevation. To add to the complexity, the NPS asked that each structure be light enough to be lifted by a helicopter but strong enough to sustain winds of more than 225 miles per hour.

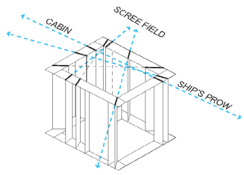
The final design solution is a series of prefabricated structural gabion walls. Each of the steel louvers between gabion modules act as a moment frame connected by a continuous ring plate above the walls. The ring plate transfers lateral loads from one leg of the moment frame to a corresponding leg on the opposite wall. This ring plate is key to the structural system, effectively bending and transferring lateral forces around the structure, allowing the moment frames to work along their lines of action. To keep the structure as light as possible the gabion rocks were collected on-site. The rocks act as ballast for the structure and laterally brace each of the 1/8" thick steel plate moment frames to prevent them from laterally buckling. This hybrid structural system allowed the steel plate louvers to be reduced from 1/4" to 1/8" plate and the gabion walls to be reduced from their original 18" thickness down to 12 inches. This minimized onsite construction, cut structure weight by nearly 40%, and reduced onsite rock collection, and therefore the impact to the flora, by 33%.



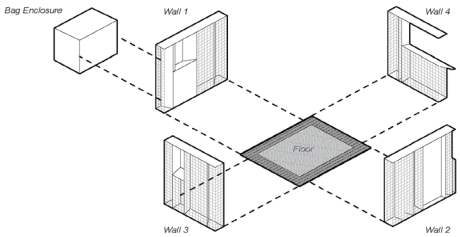
**ACCESSIBLE BATHROOM STANDARDS**
The National Park Service's ABA guidelines set the footprint of the structure.



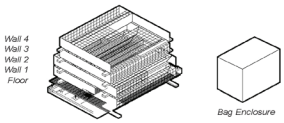
**MOMENT FRAME STRUCTURE**
Based loosely on Toyo Ito and Cecil Balmond's structural solution to the Serpentine Pavilion in 2002 the ROMO Privies used 1/8" steel plate louvers as moment frames.



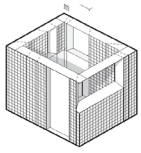

**TRIANGULATING LATERAL LOADS**
Each moment frame is adjusted to take advantage of the immediate context and triangulated to brace the structure against the winds.




**PREFABRICATION**
4" x 4" WWF is welded to the lovers to form the gabion cages. Prefabricated off-site by the students, the structures were broken down into walls and floors, and shipped to the site using a KMax Helicopter.




**DESIGNED FOR SHIPPING**
Each structure was light enough to be delivered to the remote locations using just two loads. The first was a stack of walls supported by the floor. The second was the bag enclosure.



**ON-SITE CONSTRUCTION**
Once reassembled on the mountain the cages are filled with rocks collected from the site. The gabions are loaded from the interior of the structure using WWF hatches that flip open. Once filled they are secured with bailing wire.