White Paper:

Material performance when bouldering criteria is applied

prepared by Vertical Solutions

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Executive Summary

As the popularity of indoor climbing gyms increases, so does the number of available data points in the field to use as case studies on a variety of topics important to the industry. These field examples, however old or new, are rapidly producing a diverse data set which can be analyzed to inform future decisions made by indoor climbing gym owners/operators. One analysis that can be completed due to the plethora of field examples, is choosing a material for bouldering floor usage based on the incredibly unique criteria that must be met. The criteria has been well established and documented; the usage of multiple unique materials is present from a variety of manufacturers; as a result, the solution of which material(s) perform best for a given criteria can be made. The purpose of this white paper is to document the procedure to do so, and conclusion(s) that can be made.

Problem solving is inherent to the climbing gym industry as it continues to experience growth. The exponential addition of members/climbers to the industry at large can exacerbate issues present in products used, procedures executed, and general operational deficiencies. The solution(s) to issues related to climbing gym products specifically, can primarily be solved by applying the correct material, design style, and manufacturing procedure.

This white paper will focus on an analysis of material performance based on the following pain-points common to the indoor climbing gym owner/operator/staff:

- *Overal durability*
- *Cleanability*
- *Impact resistance/absorption*
- *Tear resistance*
- *Appearance*

Please download the supplementary image library for full resolution images with corresponding labels and captions. [Download Link.] (68MB)

What follows is a comparative analysis of these criteria across three main materials found in bouldering floor applications:

- ***Heavy Duty 18oz PVC (Polyvinyl Chloride)-coated polyester (referred to here-on out as "Vinyl Sample")***
- ***Carpet Bonded Foam (referred to here-on out as "CBF Sample")***
- ***1050D Ballistic Nylon (referred to here-on out as "Ballistic Nylon Sample")***

Definition of Criteria

Durability

Problem: Due to the significant expense of flooring systems for bouldering use, replacement interval as a result of wear rate is a key factor when determining the true cost of the flooring system over the lifetime of an indoor climbing gym. For this analysis, the lifetime of an indoor climbing gym can be referenced as 20 years in order to provide a tangible duration in which to frame the discussion. The more durable a flooring material is, the less often a gym owner will have to replace it due to expected use, or even misuse.

Comparison procedure: There are several key contributors to increased wear rate in a bouldering floor. When left on its own in a vacuum with no usage, theoretically the lifespan of all materials tested would be considered lengthy by most measures. It is only when outside elements like dirt and oils from street shoes, and abrasive rubbers found on climbing shoes are introduced that we can begin to see a significant discrepancy in wear rate among materials. The procedure used in this white paper addresses this introduction by means of observing the amount of dirt deposits left on each sample using a controlled application, as well as analyzing the deformation of material top-coat as a result of applying a controlled force for a specified amount of time with a climbing shoe.

Cleanability

Problem: Climbing gym staff is typically paid on an hourly basis, and generally speaking has cleaning the facility in their job description in some form or another. Time spent cleaning the facility is detrimental to the bottom line of a climbing gym's business model. The introduction of two substances common in all climbing gyms, chalk and water (to represent all drinkable liquids), can be assumed to be responsible for most of the compulsory cleaning intervals, and therefore responsible for much of a staff-member's time, and ultimately expense to the owner. In short, the easier or more conducive to cleaning a material is, the less time that will be spent cleaning, and theoretically less expense associated.

Comparison procedure: Unlike durability which would be hard to measure without the introduction of outside wear rate elements over time, cleanability can be measured independent of time and analyzed in a controlled environment. The procedure used in this white paper introduces a controlled amount of both chalk and water discreetly, and then a cleaning procedure applied identically to each sample and results observed.

Impact resistance/ absorption

Problem: The primary purpose of flooring for bouldering use is impact attenuation of a falling climber. While not all climbers are of the same weight or size, ultimately the relationship between static deflection under load and dynamic absorption can be drawn when a controlled foam density and cell type is used. A falling climber produces a concentrated deceleration by the flooring which in-turn produces response characteristics of varying levels typically associated to “safety.” The more amicable a material is to the attenuation of a climber’s fall, the less likely a gym is to experience unpredicted injury reports (rolled ankles, sprained joints etc.).

Comparison procedure: The purpose of the procedure used in this white paper is not to identify or objectively measure what is “safe” versus “unsafe,” but rather observe the encompassing material's overall contribution to flooring system response characteristics on a system level. In short, we will not draw a conclusion as to which material is “safest” but instead indicate how each material differs from one another in respect to system response. These conclusions are drawn by analyzing a static material surface deflection under a controlled load.

Tear resistance

Problem: While not an immediate threat during intended use by the end-consumer (climbers), weekly or bi-weekly routesetting procedures produce a number of events that see the flooring system absorbing impacts and steady-state force applications of heavy tools and sharp objects. As a result, these events are prone to tear the top-coat material. Simply put: you have staff working at height with tools that can cause rips and punctures in your bouldering floor. The less prone a bouldering floor top-coat material is to tearing, the less probability a gym owner will have of unnecessary or unscheduled replacement.

Comparison procedure: There are a variety of tools and operating procedures that could produce tears in a bouldering floor. Taking a logical approach to the most common cause of tears, the goal was to replicate an impact driver with 3/8” driver bit falling onto the sample flooring at a controlled number of non-controlled angles. After all, the specific tool used in the vacuum of this white paper does not fall the same way every time during field use, so it can be assumed that the random nature of this procedure produces a real-world scenario. In addition, a standard utility knife with an unused 2.4375” utility blade was repeatedly applied to the same location, with the objective to break the surface material within a reasonable count of cuts. While this isn’t present in daily usage, it can be seen as an indicator of the worst case scenario for a bouldering floor to be subjected to sharp objects; be-it on an occasional or frequent basis.

Appearance

Problem: The most subjective of topics covered in this white paper, the appearance of a bouldering floor can not be objectively measured per se, nor should any metrics be applied to do so. With that stated, one factor that can contribute to the success of a climbing gym’s brand and cohesiveness is in fact the appearance of its facilities, of which flooring is a significant part. Having a well-maintained facility that is free of visual defects and disorder, can generally be said to produce a favorable brand image in the customer’s mind and lead to more success in organic membership growth. Boiled down into a singular thought: the less disturbed and more consistent the natural appearance of a bouldering floor looks, the more likely a customer is to view your brand as professional leaders and a premium experience altogether.

Comparison procedure: To overstate the above disclaimer: Any comparison in appearance is typically subjective as opposed to objective. It is the purpose of this white paper to illustrate two common appearance characteristics that can be attributed to most major flooring styles: top-coat surface wrinkles and seam intervals. Both of these characteristics are directly related to a smooth flooring surface free of disorder and distortion.

Definition of materials

18oz PVC (Polyvinyl Chloride)-coated Polyester
Material Specifications: Appendix A (click to view)

Carpet Bonded Foam
Material Specifications: Appendix B (click to view)

1050 Denier Ballistic Nylon
Material Specifications: Appendix C (click to view)

Material observations when bouldering floor criteria applied

Durability

Procedure Application
- Street shoe dirt/oil
- Climbing shoe rubber

Vinyl

➡Extremely fast wear rate; destructive in nature
➡Loses sheen/top coat immediately through rubber transfer
➡Any abrasive will magnify issues; high dirt attraction/deposits remained

Observations — Within two minutes of applying the climbing shoe rubber to this sample *(T1V-1)*, the material demonstrated significant deterioration to the point where the underlying construction of the vinyl was visible. It is evident in the pictures that gone is the water-repelling top-coat, gone are the colored fibers, and the sample was worn through enough to have the individual structure/ backing yarns visible *(T1V-2)*.

Applying a controlled amount of dirt with a test object, and then removing the object, it was observed that this sample attracted much of the dirt as a significant amount was remaining on top *(T2V-1)*. This when combined with abrasive rubber either from street shoes or climbing shoes, is likely to accelerate the wear on this sample even further.

CBF

➡Carpet layer frays quickly
➡Extreme amount of rubber transfer
➡Trace amount of dirt attraction; embedded in fibers

Observations — The inherent construction of this sample's top surface which consists of loose fibers commonly found in most carpets did not demonstrate desirable characteristics when climbing shoe rubber was applied *(T1CBF-1)*. The fibers quickly showed witness marks from rubber transfer which acted as a soft sandpaper, and beyond that it demonstrated significant fraying *(T1CBF-2)*.

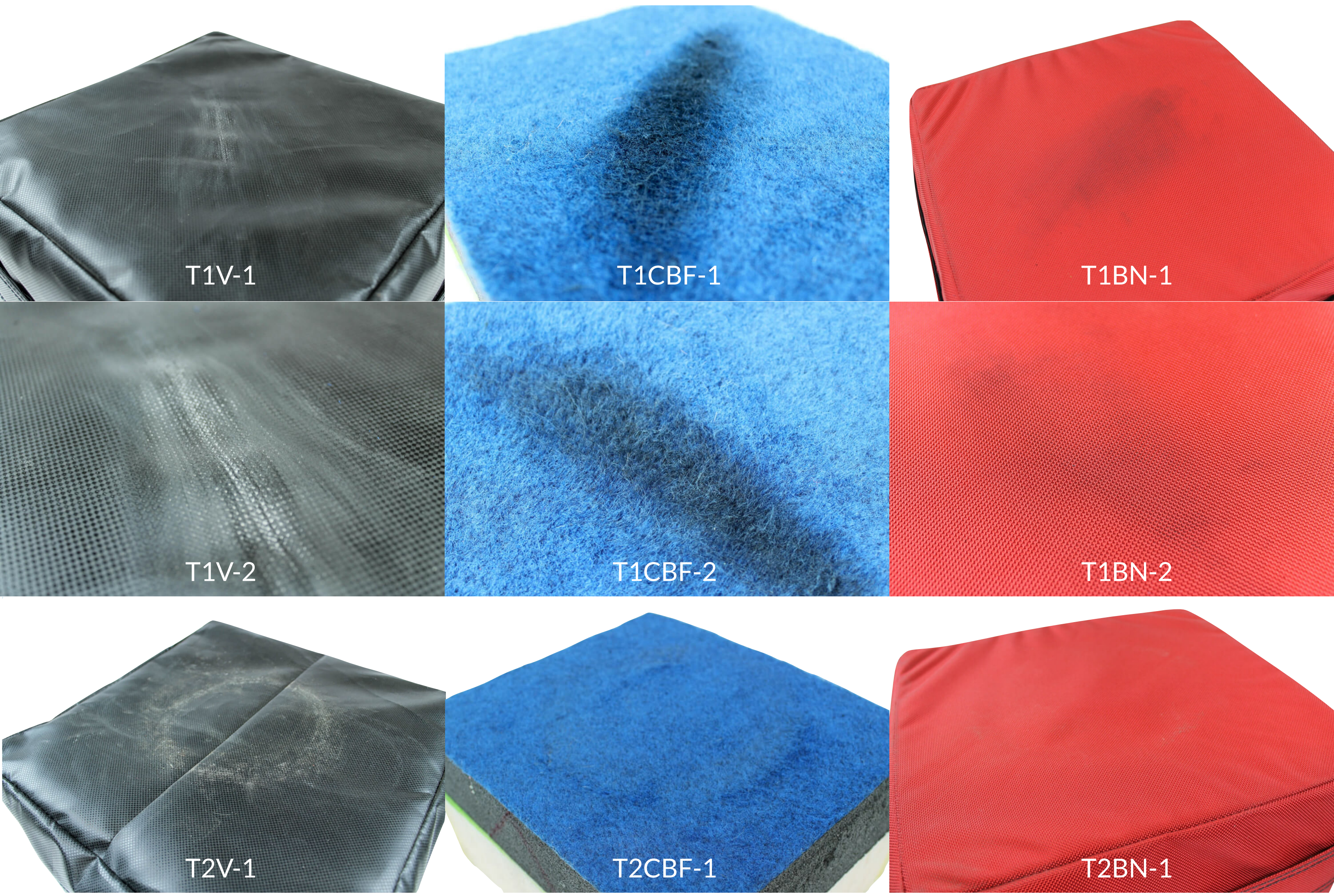
As dirt was applied with the test object, and then removed, the material performed well inexplicably. Witness marks were evident, but little dirt remained on the sample *(T2CBF-1)*. An assumption could be made that had the test object been moved in one or multiple directions with dirt on it, that a significant amount of dirt would have then remained. In this static test however, it performed better than expected.

Ballistic Nylon

- ➡Immeasurable wear rate; virtually zero
- ➡Some discoloration as a result of rubber transfer
- ➡Trace amount of dirt trapped but loose on surface

Observations — This material sample performed extremely well when subjected to the same rigorous climbing shoe procedure *(T1BN-1)*. While some discoloration did remain, indicating a limited amount of actual rubber transfer into the material weave itself, there was no distinguishable amount of material wear whatsoever. All fibers of the surface weave remained intact throughout the procedure, no distortion of any fibers existed, and zero permanent damage was observed *(T1BN-2)*.

When the control sample of dirt was applied with the test object, this material performed on par with the best sample of the set, equalling that of the CBF sample. The image shows a trace amount of dirt was attracted to the top surface *(T2BN-1)*. One could draw the conclusion that trace amount was gripped by the tight weave of the material in areas of the most contact.



Procedure Application
• Chalk and water

Vinyl
➡Mildly traps chalk, but smears
➡Water repellant if surface intact
➡Mops messy, doesn't dry well
➡Does not vacuum well; fabric creates full seal

Observations — Due to the inherent weave characteristics of this sample, it trapped roughly half of the chalk volume deposited. This is certainly a good quality to see but as shown in the images, it did so by smearing over a larger surface area to accomplish this *(T3V-1)*.

Cleaning the sample produced an undesirable result which saw the chalk only partially removed with three vacuum passes and increased the surface area yet again of the chalk deposits. Some of this can be attributed to the fabric itself having a very smooth surface that inadvertently creates a 100% seal with the vacuum, which ultimately pushes a portion of the chalk around rather than collecting it. The observed visual result was approximately 80% of the chalk removed and the remainder smeared across a larger percentage of the top surface *(T3V-2)*. As part of the auxiliary cleaning procedure, the second method of hand mopping the reminder of the chalk was applied to samples where needed. This was necessary to remove the final percentage of chalk deposits and took a couple of attempts to remove completely.

Corollary note: two methods of water application were used for this sample. The first was water in a mop application as part of the chalk cleaning procedure; the second was a controlled volume of water to represent any given liquid commonly seen in a climbing gym environment (water, coffee, kombucha etc), as part of the liquid cleaning procedure.

When a controlled volume of water was applied to the surface, the water repellant nature of its top coat performed very well. It was observed that likely zero percent of the water deposited was absorbed by the material *(T4V-1)*. Where this sample fell short was during the chalk cleaning procedure, in the areas that the top coat had been partially or fully removed due to the previously executed wear procedure. While circumstantial to this white paper, this scenario is not outside of the realm or real-world usage. The material exhibited problematic symptoms of permanent chalk deposition and immediate absorption. When the water was mopped as part of the liquid cleaning procedure, it again performed very well and was able to be mopped up with presumably zero percent of the original simulated spill still present. As a final observation, there was ample mop water legacy streaks that remained until it was fully evaporated *(T4V-2)*. The duration of this leftover water would be dependent on the local environment humidity and elevation.

CBF

- ➡Traps chalk loosely at the expense of staining
- ➡Vacuums well, not 100% pick-up
- ➡Absorbs liquids immediately making stains irreversible

Observations — This sample contained the chalk spill very well. The fibrous top-coat trapped much of the chalk deposits; potentially approaching 100% if you take into account foot traffic that would inevitably follow *(T3CBF-1)*.

Cleaning this controlled chalk spill off of this sample also produced positive results. The uneven surface produced by the carpet fibers allowed for a vacuum to pass over easily without reaching full suction, thereby giving it full potential to capture much of the spill. With that said, it was observed that this same uneven surface that created the positive vacuum results, had an adverse affect by promoting staining *(T3CBF-2)*. Extremely fine chalk residue/deposits adhered to the fibers, which resulted in an obvious witness area to the spill. While not traditionally mop-able, care was taken to apply a wet-rag to the stain and dab until the area was saturated. This is not an ideal process but was required to remove the chalk close to 100%.

When the control liquid was applied to this sample, it absorbed almost instantly; a short enough time to actually be difficult to photograph *(T4CBF-1)*. As a result, no attempt was made to remove the liquid spill beyond immediately dabbing it with a dry cloth — something that in retrospect was dissimilar to most real-world scenarios. Evaporation over time is the only foreseeable solution. Depending on the liquid, this would certainly result in semi-permanent staining. At this point, one can assume that a professional carpet cleaning system focused on commercial applications would be necessary to remove the liquid stains 100% *(T4CBF-2)*.

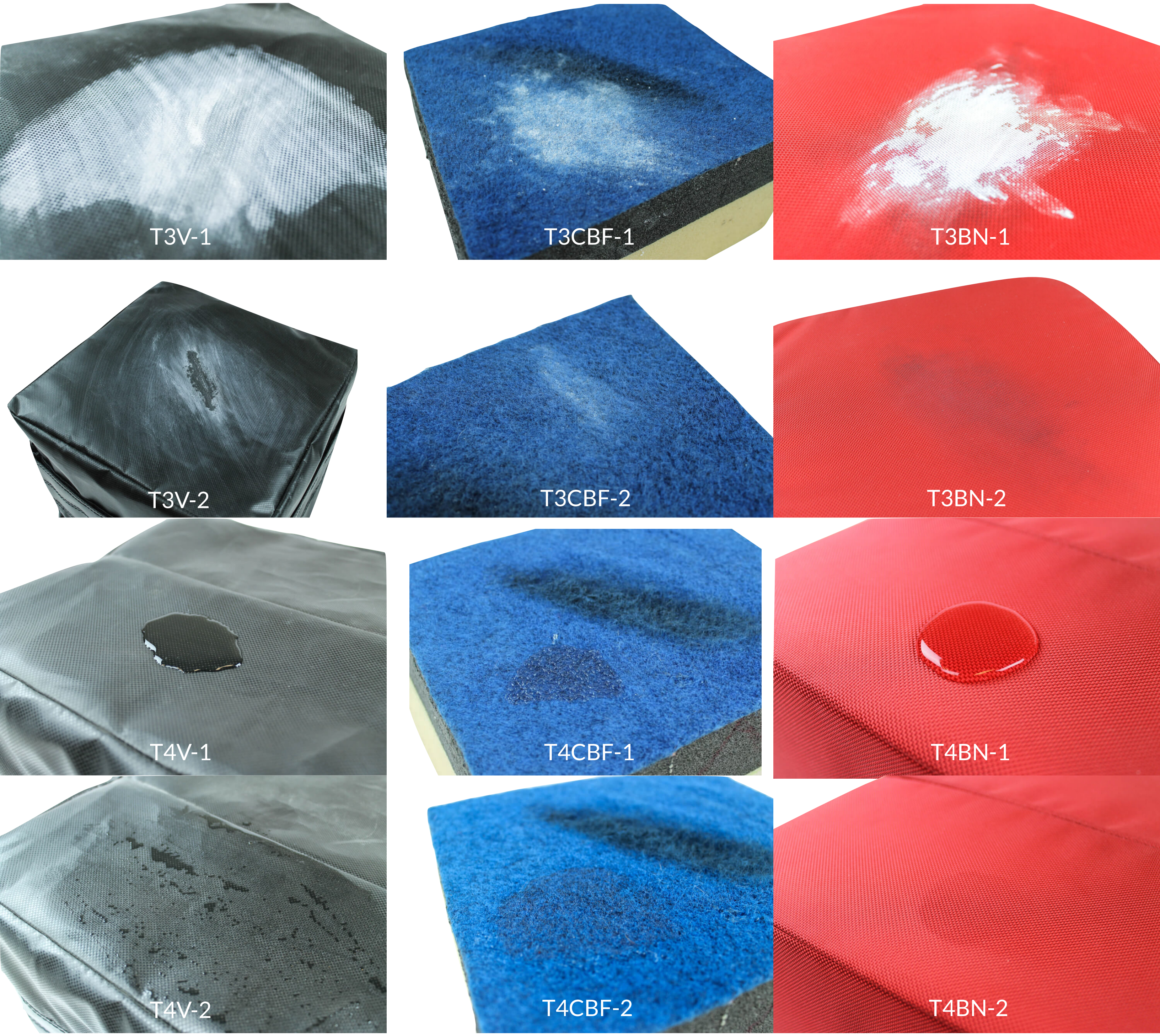
Ballistic Nylon

- ➡Traps chalk with no smearing or staining
- ➡Waterproof and stain-proof
- ➡Vacuums both chalk and liquid extremely well
- ➡Mops chalk and liquid well

Observations — This sample exceeded the results of the other samples in every capacity during the cleaning procedures. The control volume of chalk applied to the surface was almost entirely trapped by the fabric's weave design. The nylon fibers of this material oriented 90° to each other produced micro-grooves on the surface which in-turn allowed for the chalk molecules to fill in *(T3BN-1)*. While not immediately noticeable, the depth of these groves are more significant than the shallower, wider weave of the Vinyl sample while also not matching the depth of the fibrous CBF sample. The result was approximately 90% of the chalk contained in the weave, with much less spill propagation than the Vinyl sample and no staining as a result.

Cleaning the contained chalk spill was accomplished with a single pass of a vacuum, as the vacuum could not generate a sealed suction as was witnessed with the Vinyl sample. The inherent characteristics of nylon also seemed to maintain complete separation from chalk molecules, allowing them to easily be removed *(T3BN-2)*. We did note that due to the order in which the procedures were applied, the minor discoloration left by the climbing shoe rubber in the durability test turned a slightly lighter gray color after chalk was spilled on it and vacuumed up. This however was barely noticeable by the human eye and most likely unrecognizable in photos.

Applying the liquid volume to simulate a spill, this material again performed extremely well. The DWR top-coating and the impenetrable fabric backing created a fully waterproof scenario that would not allow liquid to pass through *(T4BN-1)*. One can deduce that when brand new and left alone with no other influencing elements or events, the pool of liquid would have a saturation rate much slower than the local evaporation rate. As this is not a real-world scenario, it was observed that the liquid pool remained intact for a duration more than long enough for a staff member to go get a mop or absorbing towel to clean it up. The final results were a barely damp to-the-touch area leftover that quickly dried and looked as-new. The photograph was taken immediately after cleaning, to show that the water had not spread or propagated whatsoever through the surface level *(T4BN-2)*.



Impact Resistance / Absorption

Procedure Application

• Deflection under load

Vinyl

➡Very soft & compliant overall
➡Takes on stiffness of foam below in XYZ axis
➡More deformation for a given load

Observations — When subjected to a transverse loading by a control object, this sample exhibited very soft characteristics overall and was the most compliant of the materials covered in this paper. The stress distribution of this sample was not uniform in nature and it contributed to the instability of the 70lb test object static position and balance. It was observed that this material translated most of the stress introduced by the test object directly to the integrated foam core. The result was strain in, and deformation of, the entire system (surface material and foam). This left the foam solely responsible for stabilizing the test object since the sample surface did little to contribute. When loaded with the test object, the sample's surface material wasn't a main contributor to the overall stiffness in any direction — X,Y, (lateral)or Z(vertical); rather, the foam was *(T5V-1)*. Boiled down to be applied to bouldering floor terms; this system was soft in all directions which is great for absorbing a climber's fall but could increase the probability of a rolled ankle and any off-axis impact.

CBF

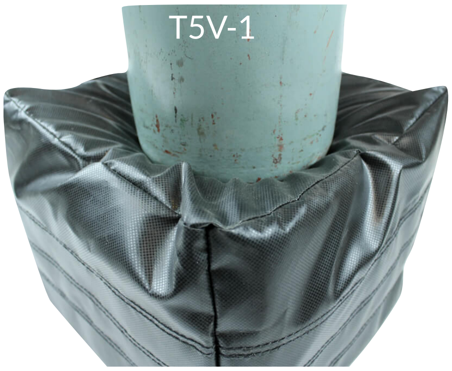
➡Very stiff and non-compliant overall
➡Carpet and foam work as one
➡Deflects little and produces bounce

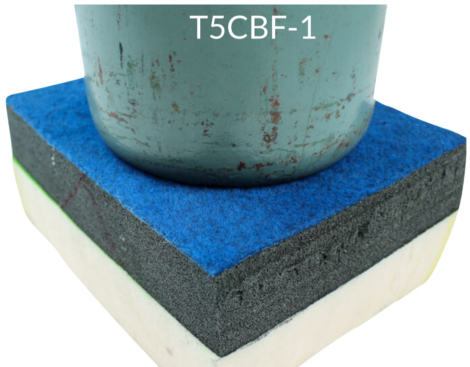
Observations — The transverse load applied to this sample produced a uniform stress distribution over the carpet bonded surface material and cross-linked layer of PE foam underneath. Very little, if any, force from the test object was translated in any direction other than Z. Both X and Y forces were completely stable, as almost all of the stress introduced was absorbed in the Z direction. We observed that both the bonded carpet and PE foam layers had very little strain, while the open-cell foam layer was heavily strained. The adverse affects of this however, saw the open-cell layer of HR foam underneath the cross-linked PE layer taking on most of the compliance *(T5CBF-1)*. This is beneficial in the case of limiting X&Y directional movements, but ultimately produces a "spring" or bouncy effect of the system as a whole. Plainly put, this sample does a good job of being stiff enough to absorb an off-axis impact from a climber's foot while decreasing the probability of rolled ankles but it comes at the expense of increasing the stiffness and spring-back characteristics of the entire system, making it harder to fall on altogether.

Ballistic Nylon

➡Tension stiffness higher than vinyl, less than CBF
➡Takes on foam compliance characteristics in Z axis, less in X/Y
➡Deflects under given load, more than CBF, less than Vinyl
➡Contributes toward stability of foam

Observations — The integral characteristics of this sample's nylon fabric weave saw it contributing to the overall stress distribution in all directions; significantly in the X & Y directions. Because the sample's surface material has a high value of tension stiffness, the deformation of the sample overall was uniform without being too soft or stiff in any direction. The core component of this sample surface material, 1050D nylon fiber, has a high modulus of elasticity when compared to other fabrics, and often surpasses that of many traditional plastics. Essentially this material allows some compliance and deformation in the Z axis together with the foam, but does so coupled with increased stability in the X & Y directions *(T5BN-1)*. Broken down in layman's terms, it allows the fabric and foam to work together in unison and arrest a climber's fall down onto the flooring, while also adding some stability to counteract ankle rolls. The stiffness characteristics of this sample can be said to be in between the very stiff CBF sample, and the soft-in-all-directions Vinyl sample.





Tear Resistance

Procedure Application

- Puncture and slice

Vinyl

➡Destructive resistance
➡Testing showed problem can compound
➡Sharper object, much less resistance
➡Cuts will propagate

Observations — The procedure outlined in this paper produced a semi-positive result from this sample. The construction of this material was resistant to the puncture impacts it was subjected to, but did so in a destructive/irreversible way. The top surface was marred with every impact, and deformation was permanent using the blunt object in the procedure *(T6V-1)*. The inherent characteristics of its material construction saw each impact plastically deforming it in an irreversible way. The ultimate result was that no impacts produced any punctures, but it stands to reason that the deformation would compound with usage, especially when coupled with deterioration due to climbing shoe abrasion and street shoe dirt.

Applying the knife procedure to this material produced a very negative result. The material's PVC-coated top surface was fully breached within 3 applications of the blade *(T7V-1)*. The core polyester construction simply did little to mitigate penetration from this sharp object. In addition to this, the material showed no resistance to cut propagation once mild pressure was applied to the surface area.

CBF

- ➡Resists punctures well, function of dense PE foam under top layer
- ➡Offers less resistance to impacts with sharper objects
- ➡Any resulting punctures unlikely to propagate

Observations — This sample performed very well in this procedure. The carpet and PE foam layers were heavily resistant to the puncture procedure using the sample blunt object. It was evident that any impact from an object of this size and force was unlikely to produce any deformation whatsoever no matter how many times the same position was struck, within reason *(T6CBF-1)*. The inherent structure of this sample has a constituent material with a high elastic modulus, which reacted with very little strain on impact. Ultimately the PE foam layer is heavily resistant to deformation, permanent or temporary. Plainly put, any tools or objects dropped by rout setters or climbers are unlikely to cause issues on this sample.

While the blunt object procedure produced highly-resistant results, the sharp object application produced similar, but not quite as resistant results. The knife used in this procedure penetrated the surface material (carpet & PE foam) after 10 consistent swipes in the same spot *(T7CBF-1)*. It is easy to conclude that this is an unlikely real-world scenario that could be reproduced by accident in a climbing gym. With that said, even with that destructive surface breach, the PE foam layer beneath is highly resistant to tear propagation and almost undetectable to the human eye from a reasonable distance. It would be accurate to conclude that the only concerns about surface punctures using this sample would be in regards to the joint seams between two pieces; a procedure well outside the realm of this white paper.

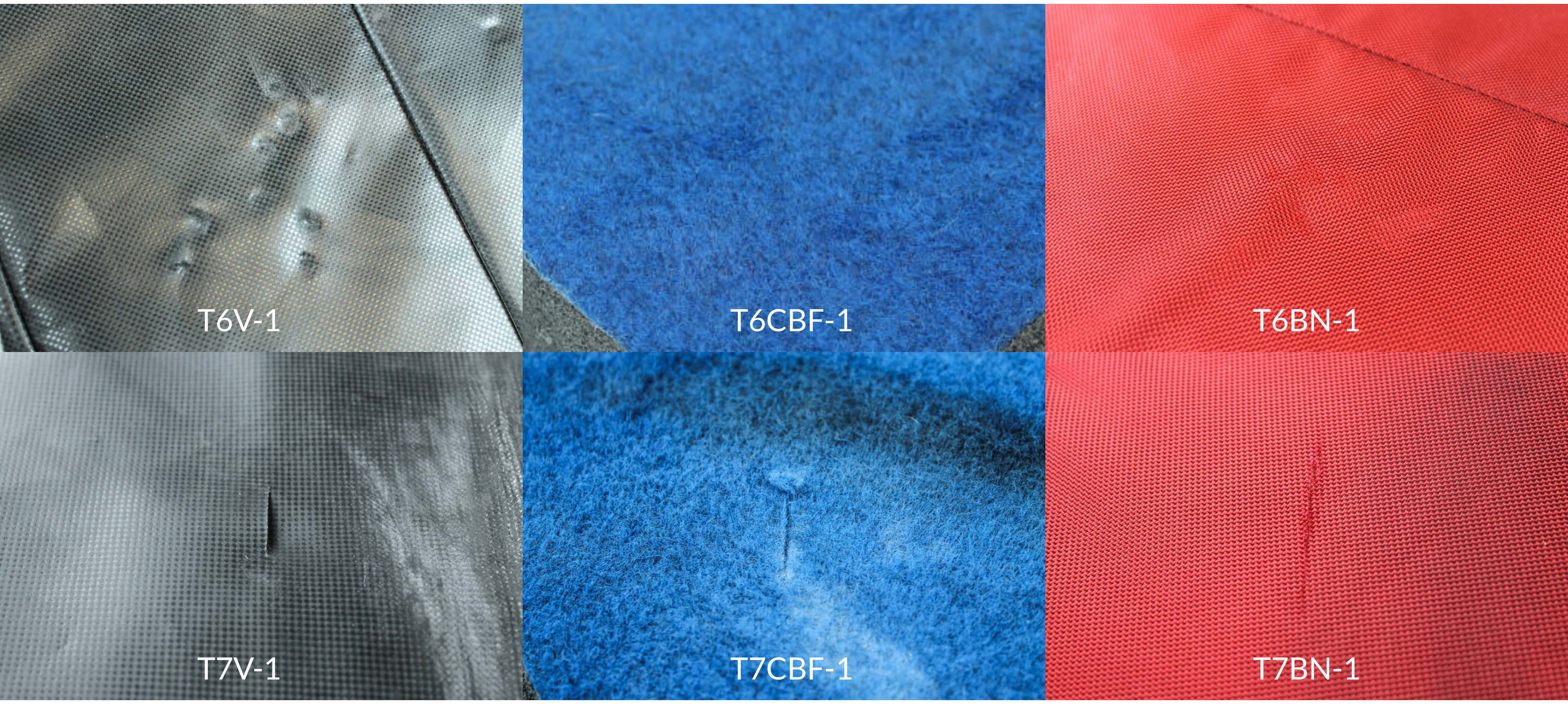
Ballistic Nylon

- ➡Resists punctures extremely well with only elastic deformation
- ➡Non-destructive resistance to blunt objects
- ➡Extensive sharp object applications produce some plastic deformation
- ➡Material construction key to performance

Observations — This sample had incredibly high resistance to the blunt object procedure, and unlike the Vinyl sample, did so in a non-destructive (elastic) manner showing no permanent (plastic) deformation. The impacts that this sample was subjected to temporarily deformed to the blunt object while completely resisting it, and returning to its original position. No surface breach was witnessed, and similar to the CBF sample, it was inconceivable that it would never be a concern in any situation seen in a climbing gym *(T6BN-1)*. This is certainly an ideal sample result given the criteria for bouldering use.

Much like the resistance this material had to the blunt object procedure, it also performed extremely well during the sharp object procedure. This material was impenetrable even after 20 consistent applications of the blade to an identical area. The procedure concluded that this number of identical cut attempts would never be seen in a realistic scenario, and ceased after the 20th. The type of resistance to sharp objects was however, semi-destructive in nature. Signs of the constituent material (1050D nylon fibers) failing as a result of repeated cuts in the same location were present after 10 attempts, and physical evidence of full plastic deformation of individual fibers arrived around cut 18 *(T7BN-1)*.

As a side note, the results of this sample material correlate to its original real-world intended usage to protect humans against high-speed airborne debris both sharp and blunt in nature. The performance implications of this material further lead to it being replaced by the ever-present and versatile Kevlar product which is famously used in body armor. Both ballistic nylon and Kevlar share similar weave construction characteristics which you can conclude would produce similar if not identical results from the procedures used in this white paper.



Appearance

Subjective Analysis

• Seams and wrinkles

Vinyl

➡Wrinkles result of elastic and plastic deformation
➡Inconsistent top-surface
➡Fewer seam breaks

As stated in the procedure definitions, the analysis performed on this sample is subjective. With that said, we are able to differentiate these samples using visual criteria. As noted in observations during the Impact Resistance Procedure, this sample exhibits the most elastic deformation of any sample tested. This translates to frequent wrinkling on the top surface that is sourced from any climber simply walking over it. In addition, the material reaches the plastic deformation point quicker and more frequently than any other sample, which results in a deformed top surface that is no longer the same dimensions as-designed in the XY plane *(A1V-1)*. Plainly put, this material is easily stretched and deformed by people walking over it or placing heavy objects on it. This change in the surface however small, is irreversible and creates extra material that bunches up together and forms wrinkles.

A major positive of this material sample is the lack of major seam breaks in the design as a whole. Sheets of this material can be constructed together to form a flooring design with minor seams (every 8 feet) that is only limited by the constructor's manufacturing capabilities. The downside of this is that should the top-surface suffer any punctures or cuts, the replacement procedure is often a patch-and-glue system which introduces additional inconsistent top-surface characteristics.

CBF

- ➡Consistent top-surface free of wrinkles
- ➡Uneven surface due to many hard seam breaks
- ➡Irreversible deformation

This material has a top surface that is much more consistent and resistant to elastic or plastic deformation, and as a result does not stretch or compress when walked or fallen on by climbers, and therefore, no wrinkles will be produced. Most elastic deformation in this system is attributed to the underlying open-cell foam, and will not affect appearance on the surface.

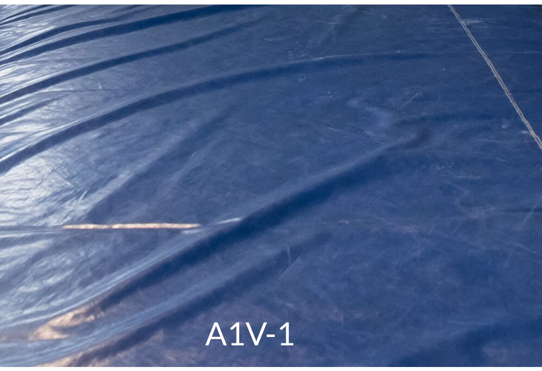
Where this material falls short however, is in the major seam breaks which are hard-limited to material roll width: typically 8 feet. The compliance of the underlying open-cell foam as mentioned above, creates extremely inconsistent seam breaks, which produce a very uneven surface *(A1CBF-1)*. This uneven characteristic can be addressed in a very minor way by applying seam tape which must be replaced on a relatively frequent basis. It does not however, eliminate the possibility of each 8 foot section growing or contracting at uneven rates, which produce bulges and gaps. This is due to there being no internal reinforcement features that limit lateral movement. These bulges and gaps wind up being permanent as there is no reversing procedure to correct the situation. The problem is also compounded due to the frequency in which seam breaks are present in any CBF-based flooring design. The more breaks in the flooring surface; the more probability there will be a mis-aligned and deformed surfaced.

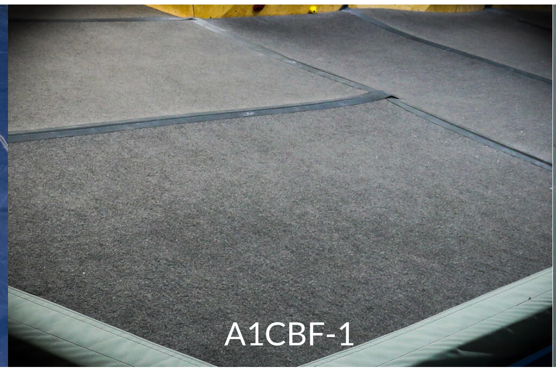
Ballistic Nylon

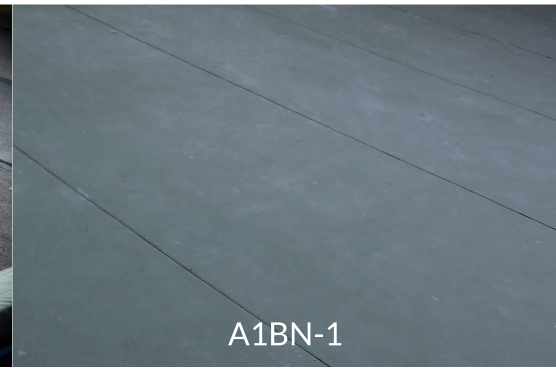
- ➡Hard to produce wrinkles; can be adjusted as needed
- ➡Few seam breaks due to large uniform section manufacturing capability
- ➡Uniform construction and appearance with little deformation

This material sample has a high resistance to surface deformation due to its tension stiffness. It supplies ample compliance for climbers walking and falling, without any plastic or irreversible deformation *(A1BN-1)*. With that said, it is not completely impervious to wrinkles as the advantageous stiffness of the material's weave does not lend it to absorbing shear forces well (in the X & Y axis). It is for that reason that the inherent system's design sees occasional maintenance needed to re-adjust the top-shell to bottom-shell velcro joints which are placed on the vertical surfaces of the floor, rather than the horizontal top-surface.

Similar to the Vinyl flooring system design, the limiting factor on frequency of hard seam breaks will be the manufacturer's own facility capabilities. This material's flooring design typically sees large uniform sections of 1,000 sq.ft. each, only consisting of minor hidden seams at 8-foot intervals. The result of this is fewer hard seam breaks with fewer seam covers. The result is a consistent top-surface with no deformation, fewer seam breaks, and a uniform construction.







Conclusion

Overall Material Performance

When the bouldering gym criteria defined in this white paper were applied to the three most common materials found in existing products, every sample suffered weaknesses to some degree. As in most industries, there is never a "silver bullet" that transcends the laws of physics; there are always trade-offs. Through a thorough analysis one can determine what those trade-offs are and which criteria is most important to have the highest performing material for a given application.

Through the procedures outlined in this paper, the material found to have the least amount of negative drawbacks is the 1050D Ballistic Nylon sample. It was not only the most climber-friendly in terms of absorbing impacts and mitigating potential injuries, but it also exhibited the most gym owner-friendly characteristics by being extremely resistant to wear events, deformation, and being the least difficult to clean by far. When it showed minor signs of weaknesses, they were muted at worst. When it outperformed other samples, it was by a large margin. This, coupled with the long-term implications of the results make it the top-choice for climbing gym owners.

The vinyl sample performed well in response to a number of procedures but suffered many drawbacks as a result of its general construction method and material characteristics. This sample has been the de-facto standard for many years in gymnasium flooring (not specifically climbing related) but the bouldering-specific criteria procedures carried out in this white paper exploits situations not commonly seen in standard gymnasium usage. The durability concerns alone of this material suggest that a gym owner would be replacing it on a much more frequent basis than the other two samples. This, coupled with it not outperforming either of the other two samples in most categories eliminates it from being the most ideal choice.

Carpet Bonded Foam had a number of advantages in regards to bouldering usage specifically, but the amplitude of the drawbacks were extremely high. To be blunt: it performed well until it didn't: and when it didn't, it missed the mark by a substantial margin. The irreversible nature in regards to outside elements commonly seen in climbing gym usage (spills, dirt, humidity etc) is a substantial limitation of this material overall, and the weaknesses specific to bouldering usage (very high impact resistance, consistent design challenges); even more so. This sample has enjoyed long success in a route climbing floor application, but the procedures outlined in this white paper implicate that it is not ideal to crossover into the bouldering application.

1050D Ballistic Nylon is emerging in the indoor climbing world as the go-to material of choice for bouldering usage. A list of popular climbing gyms that have already proven this material's performance over time through day-to-day real-world usage is located here: Boudlering Floors. It is recommended that you contact their respective owners and discuss with them their own decision making process, and how it could apply to your own bouldering floor project.