



Harlequin Liberty[®] Switch Stage Floor System

Application Study

Completed March 2024

Adapted for American Harlequin Corporation June 2024

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**APPLICATION STUDY FOR LIBERTY SWITCH FLOOR
BY HARLEQUIN FLOORS**

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March 2024

1. INTRODUCTION

- 1.1 Liberty Switch is a dance floor first and a theatre floor second.
- 1.2 This study is to discuss potential applications of the Liberty Switch product by Harlequin Floors and what it can offer venues in terms of economy of resource - in manpower, time, space and materials. What it offers programmers in terms of flexibility for use of a stage or rehearsal room and therefore can increase the intensity of use and income generation of a venue.
- 1.3 As a product, Liberty Switch has many sustainable aspects to its design.

2. WHEN AND WHY DANCE FLOORS ARE SPECIFIED FOR PERFORMANCE SPACES.

- 2.1 There are some forms of dance that require a hard floor finish with minimum deflection, where the dancers' feet and shoes act with the floor in a percussive way, for example flamenco and some Indian dancing. For these dance forms, the floor surface is often wooden to take the knocks of the foot movement and to sound in time with the rhythm of the movement.
- 2.2 For dance forms that use thin soled shoes (such as ballet and Scottish dancing shoes) or bare feet, then the floor needs to have some 'resilience' (low stiffness). An even distribution of load through the floor is important so that wherever the dancer lands, they receive the same 'give' (deflection) from the floor to reduce their acceleration.
- 2.3 Where sprung floors are recommended for dance, it is to protect dancers from damage to their muscles and ligaments. As well as protection from damage on vertical impact, there is also protection from slipping or braking too abruptly due to the surface treatment of the floor. If the floor is too polished or smooth (ie has a low coefficient of friction) then there is a danger of slipping and falling if the weight on landing is not balanced. If the floor is too sticky or too soft (ie has a high coefficient of friction), then there is a danger of the foot not sliding enough and injuries occurring when the dancer's body continues to move in the same direction and the foot stops.
- 2.4 It is important that the floor surface for dance is continuous so that there are no trip hazards, gaps or vertically offset junctions. Temporary dance floors need to be completely flat and smooth, whether a thin floor finish layer which is taped together at the edges or a panelised floor which is locked in position.
- 2.5 Dance floors can help dancers' well-being and reduce tiredness by avoiding a shock to their joints and tendons, and also not absorbing too much of their energy on impact.

3. REGULATIONS

- 3.1 The only regulation that exists for sprung floors is for the sports industry. It is EN14904 and supersedes DIN 18032.
- 3.2 Many sports floors are specified for sports where the movement is a series of short sprints, stopping and turning and these floors have different characteristics compared to floors for dance where the movement is continuous and flowing.
- 3.3 The dance industry has adopted EN 14904 regulation on the basis that the wellbeing of the human body is similar whether the jumps and landings are for sport or dance. However ballet is unique in dancing on pointe and differs from sport in the thickness of sole compared to training and sports shoes which have additional layers to absorb the shock of impact. All sports/dance floors need to have a continuous surface so that tripping is avoided.
- 3.4 A recent study using motion capture technology has highlighted the differences between dancers and athletes in their landing techniques (dancers having a more

protective technique for their musculoskeletal health) and it may be that, with further study, the floor requirements for dance can be more nuanced.

- 3.5 Ideal dance floors protect the dancers from injury, slow the onset of tiredness and support the dancers so they are motivated to dance at their fullest ability.

4.0 TYPICAL LOCATIONS FOR DANCE FLOORS

4.1 Large producing performance spaces – Opera Houses 1200 – 2000 seats

- 4.1.1 The physical effort by an opera singer to perform a whole opera unamplified is such that it is good practice for opera singers to rest their voices for a day between performances. This leads to a rotation of 2 or more operas using different casts within the same week, whether the opera house is used all year round or only for summer festivals. These opera houses are known as Repertory Houses compared to Stagioni Opera houses where one production remains on stage for a period of time with 2 alternate casts.
- 4.1.2 Where a ballet company shares a theatre with an opera company (Royal Opera House Covent Garden, Metropolitan Opera House, Garnier Opera House Paris, or Staatsoper Berlin Unter den Linden), then the ballet can perform on alternate days to rest the voices of the singers.
- 4.1.3 Historically all stages in 18th and 19th century opera houses were raked so that the audience sightlines from all balcony levels would be good, especially in the pit level (later renamed the stalls), and that performers at the front of the stage (downstage) would not mask those further back (upstage). Dancers had to cope with the increased distance that they would travel during a jump before landing downstage on a raked floor. Raked stages also increase the apparent size of performers and help the overall view of the choreography. The Garnier Opera House has a ballet rehearsal room at the back of the mainstage at the same incline of rake as the main stage.
- 4.1.4 With the advent of mechanised stage floors, raked floors have gradually been replaced with horizontal floors and dancers are more used to dancing on the flat with fewer consequent injuries.
- 4.1.5 In most forms of dance performance, it is important to have clear floor space for the dancers to move and jump therefore the scenery is minimal, often hung drapes and gauzes and located towards the periphery of the space.
- 4.1.6 For opera, the sets can be massive, three dimensional and even with closed in ceilings above the performers. The requirements for strength and stiffness of an opera house stage can be very high and therefore the stage itself and the stage machinery (if there are stage lifts) have to withstand loads and surface scraping that leads to a solid multi-layered floor construction. Stages often have sacrificial floors to receive nails to support scenery and therefore the stage construction is not compatible with the resilience and finish required of the ballet floor, so a separate ballet floor is usually added on top.
- 4.1.7 In 20th century opera houses, a separate store and dance floor wagon is provided for the permanently intact dance floor, either below the rear stage in its own housing or stored vertically at the back of the stage, and is moved into place by a team of stage staff when needed.

4.2 Large Receiving Performance Spaces - Multipurpose Theatres 1800-2500 seats

- 4.2.1 Some receiving houses, especially in North America, cater for musicals, dance and orchestral concerts on their stages. They have large stages, portable dance floors and also a requirement for an orchestral shell within the stage house for concerts.
- 4.2.2 The heavy side panels/ towers of the orchestra shell need a stiff and strong stage floor incompatible with the dance floor. The time involved in adding a dance floor on

top of the large stage area can limit the programming possibilities for the theatre which is dependent on quick turnarounds between visiting companies.

4.3 Large Performance spaces – Dance Theatres and Schools

- 4.3.1 Permanent dance spaces- such as in Dance Schools can retain their dance floor in place and determine that only people in dance shoes have access to the space, so the top surface can remain in place. Permanent dance floor finishes can be built on a fully sprung sub floor.
- 4.3.2 Sometimes permanent dance rehearsal spaces turn into performance spaces with audience seating on one side. With the increased production values comes the need to access production lights, projectors etc which potentially conflict with the surface of the dance floor.

4.4 Medium performance spaces - multi-purpose theatres, musical theatre 400-800 seats

- 4.4.1 This scale of theatre often has a regular turn around between different types of performance, but with a small technical team. Any dance floor is likely to be portable and assembled when needed on top of another floor. The different requirements for theatre scenery from dance scenery, access to performance lights from below on the stage and the load that the access equipment exerts on the floor are reasons why the dance floor needs to be portable.
- 4.4.2 Flexibility of use always requires additional space for storage of equipment needed for some of the uses.

4.5 Dance Rehearsal Studios

- 4.5.1 There are multiple hours of choreography rehearsal needed for every hour of performance, therefore enough dance rehearsal spaces are vital. The less time that is needed in putting down a suitable dance floor, the more time is available for rehearsing, the better for the use of the space and the quality of the performance. Where possible one rehearsal studio dedicated to dance helps with programming rehearsal time.

5.0 REASONS FOR FLOORS TO HAVE LOADING REQUIREMENTS BEYOND THOSE OF DANCE

5.1 Working at Height equipment

- 5.1.1. Twenty years ago, lightweight means of access, such as ladders and tallscopes, were the solution for focussing fixed performance lights above a stage or rehearsal floor. With an emphasis on health and safety at work and associated legislation, these lightweight elements have been replaced by heavier mechanisms. Mobile Elevating Work Platforms (MEWP) track on heavy wheels with enough ballast at their base to balance the load of 1 or 2 people in a cradle at 6-9m height. While the point load of the wheels on the stage floor can be compatible with the point loads required for dance from the same surface, the overall capacity of the floor loading is increased.
- 5.1.2 The weight of MEWPs has led to a move away from tongue and grooved timber floor finishes to a plywood upper deck where the intrinsic laminated structure spreads the load further and the floor layer is less subject to splitting with eccentric dynamic point loads from heavy moving equipment.

5.2 Wagons or seating towers moving over floor surface

- 5.2.1 In multipurpose theatres, the location of the stage may vary within the room for different uses. For example it can be central (in the round), at one end (end stage) or

with audience on three sides (thrust). This can mean that seating wagons, seating towers or retractable seating units have to pass over the playing area.

- 5.2.2 The wagons or towers may incorporate wheels or air castors, the former being in contact with the floor when moving, the latter floating on an air cushion over the floor.
- 5.2.3 When the whole floor is a sprung floor construction, the point loads, particularly the dynamic point loads of the wagons, need to be less than the point load of the floor design. Sometimes this is difficult to achieve.
- 5.2.4 In these multi-configuration spaces the stiff and flexible floor areas may vary per production.

6.0 HOW DANCE FLOORS HAVE EVOLVED

- 6.1 To suit the different floors found in existing buildings, a suite of dance floors has been developed for each condition. Permanent dance floors can be basketweave, ie fully sprung with a thin and soft top layer to give a softness to landing.
- 6.2 Temporary dance floors placed on top of stages can be several layers thick to give the resilience required. They can be modular panels locked together with a small perimeter ramp to deal with the change in floor height with the sides of the stage. Or they can be rolls of thin dance flooring over an already resilient floor in which case they are laid out and taped together.
- 6.3 Whatever their construction, the floor must be able to absorb the force when a dancer or athlete lands on it, by which it needs to move in the vertical plane, yet not so much that it disturbs other dancers/athletes standing nearby.
- 6.4 There are academic papers available within the sports injury world which comment that injuries are greatest on floors that have a large variation of deflection over an area.

7.0 LIBERTY LATCHLOC FLOOR

- 7.1 The Liberty LatchLoc floor is a sprung floor product from Harlequin floors that can be used as a permanent or portable floor. To achieve an even finished surface the standard 2m x 1m panels are laid in a tessellation of alternating rows of panels with 1m x 1m panels creating the end area. This means that the centre of each panel is in contact with two corners of adjoining panels on each side. By locking the panels together with coffin locks at strategic points, the panels all work together to give an even deflection throughout the floor area. The finish of the multi-layered system is wood and depending on the type of dance, a range of vinyl floor finishes can be laid over the top to give the right surface.
The Liberty LatchLoc floor can be laid either as a permanent floor or a temporary and removable one.
- 7.2 Cost
The difference in capital cost between a Liberty LatchLoc Permanent floor and a Liberty LatchLoc temporary floor is not significant, however the permanent floor uses less material and has less depth than a separate permanent stage floor with the temporary dance floor on top of it.
- 7.3 Storage requirement*

Liberty LatchLoc Permanent	None
Liberty LatchLoc Portable	12m x 12m - 4 panel carts and 1 vinyl cart 15m x 15m - 6 panel carts and 2 vinyl carts
- 7.4 Time for turnaround Liberty LatchLoc Permanent
N/A but cannot take some heavy loads without spreader ply on top

*see Appendix 2 for metric to imperial conversion

Liberty LatchLoc Portable 4 people 0.5-1 day = 2- 4 person days to put down plus the same to remove

8.0 LIBERTY SWITCH

- 8.1 The Liberty Switch takes the resilience of a Liberty floor and combines it with a rigid floor setting at the 'touch of a button' that allows for a greater range of use on the same floor eg dance and theatre. For production support, Liberty Switch allows the use of MEWPs without the reduction in hire time or the added cost due to employing people to put down and take up a temporary dance floor.
- 8.2 Cost Around 4 times the cost of a Liberty permanent or temporary floor dependent on the nuances of the control system.
- 8.3 Storage requirement
None
- 8.4 Time for turnaround
30 seconds – dependent on size of floor

9.0 WHERE LIBERTY SWITCH SAVES RESOURCE

9.1 Liberty Switch is a highly sustainable product

- It uses fewer natural resources than a portable dance floor on top of a stage.
- It takes one thousandth (0.1%) of time in the changeover of the floor from dance to theatre and vice versa.
- This opens up more time for rehearsals on stage or in the studio.
- It saves greatly on manpower and running costs (up to 2 person days per changeover).
- It saves on storage space for portable floor panels, the cost of building storage space to house them and the embodied carbon costs of the storage space.
- Other space saving options are possible in buildings with more than one studio space. For three studio spaces and upwards, a Liberty Switch floor in one studio could reduce the number of spaces needed to support the same dance and theatre programming by one space.
- The embodied carbon of the floor walls and ceiling of that one space would be saved.

Every one of these factors contributes to the product being more sustainable and useful than a lower capital cost product that takes hours out of the timetable to turn around.

The predicted lifetime of a dance floor is 20 years. In the examples below the payback period of a Liberty Switch over a portable dance floor can be calculated.

9.2 Materials

Whereas a portable dance floor on top of a stage floor duplicates some of the stage floor construction layers, the Liberty Switch uses only 3 layers of floor for both dance and theatre functions. In a new building, the stage floor finishing layers would be saved, and the Liberty Switch floor would be set on top of the stage joists or slab.

9.3 Time

- 9.3.1. The key resource that Liberty Switch can save is time. Instead of taking half a day to day and 4 people (2-4 people days) to lay a portable dance floor, the change can take place in 1 minute at the touch of a button. This positively increases the number of times a dance use can be alternated with other uses. It makes programming the space more flexible.
- 9.3.2. This allows the same space to be used at different times for dance, technical set up, and theatre with the minimum of changeover time. Time is always critical in

education buildings where the day is divided into periods and small to medium community venues where different users hire the same space in one day.

- 9.3.3 In countries where there is a strong touring tradition between cultural spaces in each town, the daily technical turn over has been designed in with movable access bridges overhead leaving the floor clear. Having a floor that can switch from solid to sprung would offer further time saving between shows.
- 9.3.4 The investment of 1 day – 2 days per time to change the floor with a portable system affects the programming of the space and the likelihood that the floor will have to remain in place for several days to be efficient in cost. The Liberty Switch frees up both the programming and the time available for the use of the space.
- 9.3.5 In countries where subsidy for the arts is less, the extra time that the building can be used for rehearsal or additional performances has distinct value.

9.4 People

9.4.1 Along with time saving, there is the saving on crew costs which can be incurred in 2 ways:

- If the existing floor is sprung, the putting down of plywood spreader panels to take additional loads from access equipment or
- if the floor can take these loads, then the laying of a modular portable dance floor on top. By being built-in, the Liberty Switch mechanism saves on the time spent by the crew to lay for either of the above situations. For new buildings, the permanent crew can be fewer for a given range of activities and the running costs can be greatly reduced.

Example:

Theatre with regular dance activity. Portable dance floor – 1 day to install and take away x 4 people. Say 40 turnarounds per year 40 days per year x 4 people = 160 days. With a Liberty Switch this time can be reduced to 40 mins for one person. While the investment can seem high, at current rates for crew per day, the payback period can be less than 2 years for a weekly dance floor need and less than this for more frequent changeovers.

9.5 Space

9.5.1 Wherever a portable dance floor is needed, there is the addition of space needed for the trollies and rolls of vinyl to be stored when the stage floor is in its un-sprung mode. Space is tight in all performing arts buildings and storage space is precious. If some of this space can be freed up by having both stage floors and sprung floors in one installation, this is a further benefit.

For new buildings, this saves on overall building area and therefore embodied carbon.

Example:

Space needed to store an area of dance floor with carts for floor panels and roll carts for vinyl finish.*

- 8 x 8m dance floor = 2 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 11 sq m storage room floor area.
- 10 x 10m dance floor = 3 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 15 sq m storage room floor area.
- 12 x 12m dance floor = 4 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 18 sq m storage room floor area.
- 15 x 15m dance floor = 6 trollies at 2.4m x 1.5m and 2 vinyl rolls at 2.4m x 1.5m = 29 sq m storage room floor area.

*see Appendix 2 for metric to imperial conversion

9.6 Costs

9.6.1 Although the Liberty Switch costs approximately 4 times more per square metre than the portable modular floor, there is no storage requirement, and this saves on total capital cost.

The storage requirement for a portable Liberty LatchLoc Floor and rolled covering is based on the required number of trollies and carts to handle the floor modules and rolled coverings.

Assumptions for examples below:

Based on current building costs, the unit cost per m² of building a store room just offstage is approximately 16 x the m² cost of a Liberty LatchLoc portable floor.

The cost of an existing floor is not counted when an existing building already has a rigid stage floor that is satisfactory for non-dance events, and a portable Liberty dance floor is to be laid on top.

The control system controls the entire area as one for a Liberty Switch floor.

Example*:

- Theatre with 8x8m floor. The total outlay for Liberty Switch is only 3% more than the cost of the portable floor and its storage area.
- For a 10x10m dance floor the cost of the Liberty Switch is approximately 14% more expensive than the portable floor and its storage.
- For a 12x12m dance floor the cost of the Liberty Switch is approximately 30% more expensive than the portable floor and its storage.
- For a 15x15m dance floor the cost of the Liberty Switch is approximately 27% more expensive than the portable floor and its storage.

10.0 CONCLUSION FOR COST IN USE OVER LIFESPAN

10.1 The expected life span of the Liberty floor and Liberty Switch is 20 years.

Say the capital cost of Liberty Switch is 4 times that of portable Liberty LatchLoc dance floor, sq m for sq m. The payback period can be as little 2 years if there is a frequent need for a regular dance floor use.

10.2 Once the costs of the storage area and building materials associated with a temporary dance floor are added, the extra costs of a Liberty Switch system needing no storage reduce considerably.

10.3 Liberty Switch can be designed with further refinement of zoned areas of floor that are operated separately, depending on the demands of the programming and the scenery, wagons and towers moving over it.

10.4 Depending on the individual priorities of each project, it is relatively easy to justify the increased capital expenditure in reliable use and longevity of the product.

*see Appendix 2 for metric to imperial conversion

APPENDIX

Case Study – Dutch National Opera Company

The Dutch National Opera Company has a flown-in dance floor which sits on a compensator elevator. The dancers require a resilient run off area at the side of the stage. This currently requires the stage crew to build up the floor at the sides of the dancing area each time the dance floor is used in repertory with the Opera company. The changeover between Opera and Ballet is frequent and therefore this repetitive task is costly in person hours.

Substituting the stage floor runoff areas at the sides of the compensating elevator with Liberty Switch will enable the run off floor to be as resilient as the existing dance floor (when lowered to the same level as the stage on the compensating elevator). At the flick of a switch, the resilient floor can become a fixed stage floor and, with a built-in thicker top layer, can withstand the wagon and tower loads of the opera productions. This will save considerable operational costs for the company and free up the time for the crew to attend to other aspects of their role.

APPENDIX 2

Metric to Imperial Conversions

7.0 LIBERTY LATCHLOC FLOOR

7.3 Storage Requirement Liberty LatchLoc Portable

Metric

12 x 12m - 4 panel carts and 1 vinyl cart
15m x 15m - 6 panel carts and 2 vinyl carts

Imperial

40' x 40' - 4 panel carts and 1 vinyl cart
50' x 50' - 6 panel carts and 2 vinyl carts

9.0 WHERE LIBERTY SWITCH SAVES RESOURCE

9.5 Space

9.5.1

Example:

Space needed to store an area of dance floor with carts for floor panels and roll carts for vinyl finish.

- 8 x 8m dance floor = 2 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 11 sqm storage room floor area.
 - **Imperial** 25' x 25' dance floors = 2 trollies at 4' x 8' and 1 vinyl roll at 4' x 8' = 120 sq ft storage room floor area.
- 10 x 10m dance floor = 3 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 15 sqm storage room floor area.
 - **Imperial** 32' x 32' dance floor = 3 trollies at 4' x 8' and 1 vinyl roll at 4' x 8' = 160 sq ft storage room floor area.
- 12 x 12m dance floor = 4 trollies at 2.4m x 1.5m and 1 vinyl roll at 2.4m x 1.5m = 18 sqm storage room floor area.
 - **Imperial** 40' x 40' dance floor = 4 trollies at 4' x 8' and 1 vinyl roll 4' x 8' = 195 sq ft room floor area.
- 15 x 15m dance floor = 6 trollies at 2.4m x 1.5m and 2 vinyl rolls at 2.4m x 1.5m = 29 sqm storage room floor area.
 - **Imperial** 50' x 50' dance floor = 6 trollies at 4' x 8' and 2 vinyl rolls at 4' x 8' = 315 sq ft storage room floor area.

9.6 Costs

9.6.1 Although the Liberty Switch costs approximately 4 times more per square metre - 4 times more per square foot – than the portable modular floor, there is no storage requirement, and this saves on total capital cost.

The storage requirement for a portable Liberty LatchLoc floor and rolled covering is based on the required number of trollies and carts to handle the floor modules and rolled coverings.

Assumptions for the examples below:

Based on current building costs, the unit cost per m² of building a store room just offstage is approximately 16 x the m² cost of a Liberty LatchLoc portable floor.

- **Imperial** Based on current building costs, the unit cost per square foot of building a store room just offstage is approximately 16 x the square foot cost of a Liberty LatchLoc portable floor.

Example:

- Theatre with 8x8m floor. The total outlay for Liberty Switch is only 3% more than the cost of the portable floor and its storage area.
 - 25'x25'
- For a 10x10m dance floor the cost of the Liberty Switch is approximately 14% more expensive than the portable floor and its storage.
 - 32'x32'
- For a 12x12m dance floor the cost of the Liberty Switch is approximately 30% more expensive than the portable floor and its storage.
 - 40'x40'
- For a 15x15m dance floor the cost of the Liberty Switch is approximately 27% more expensive than the portable floor and its storage.
 - 50'x50'

10.0 CONCLUSION FOR COST IN USE OVER LIFESPAN

10.1 The expected life span of the Liberty LatchLoc floor and Liberty Switch is 20 years.

Say the capital cost of Liberty Switch is 4 times that of portable Liberty LatchLoc dance floor, sqft for sqft. The payback period can be as little as 2 years if there is a frequent need for a regular dance floor use.

This study is to discuss potential applications of the Harlequin Liberty Switch product and what it can offer venues in terms of economy of resource.

Key Takeaways:

- Liberty Switch is a dance floor first and a theatre floor second
- It is a fully customizable product that takes the resilience of a Harlequin sprung floor and combines it with a rigid floor setting at the 'touch of a button' that allows for a greater range of use on the same floor
- Liberty Switch is a highly sustainable product with an expected lifespan of 20 years, saving resources in
 - Materials
 - Time
 - People
 - Space
- The payback period can be as little as 2 years
- Depending on the individual priorities of each project, it is relatively easy to justify the increased capital expenditure in reliable use and longevity of the product

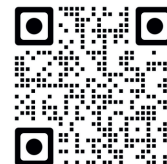


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