AS/RS Sizing & Cost Estimation:

Accurate estimate of the cost of an AS/R System could be obtained by summing the costs of:

- the storage rack, (# of unit loads, cubic size of the unit load, the weight of the unit load and the height of the rack;)
- the S/R machine, and (height of the AS/R System, weight of the unit load, type and location of the S/R machine controls)
- the building used to house the AS/R System. (height, cost per square foot to construct a 25 ft-tall building)

X = depth of the unit load (in)

Y = width of the unit load (in)

Z = height of the unit load (in)

V = volume of unit load in cubic feet $= \frac{XYZ}{1728}$

w = weight of the unit load in pounds

W = Width of the aisle of AS/RS storage in inches

L = Length of an aisle of AS/RS storage in inches

H = Height of an aisle of AS/RS storage in inches

n = number of tiers or levels of storage

m = number of columns of storage per aisle side

a = number of storage aisles

BH = Building height

BW = Building width

BL = Building length

∂ = allowance, measured in feet

α = parameter for computing rack cost, ($)

ν = weight parameter for computing S/R machine cost, ($)

β = height parameter for computing S/R machine cost, ($)

ϕ = control parameter for computing S/R machine cost, ($)

δ = cost per square foot to construct a 25-ft-tall building.

CF = Conversion factor for converting cost per sq. ft to construct a 25-ft-tall building to the cost per sq. ft. to construct a building height, BH.

The dimensions of a storage aisle:

$$W = \begin{cases} 3(x + 6'') & \text{(with in-rack sprinklers)} \\ 3(x + 4'') & \text{(without in-rack sprinklers)} \end{cases}$$

$$L = m(y + 8'')$$

$$H = n(z + 10'')$$

The dimensions of the building:

$BH = H + 48$ in.

$BW = aW + 24$ in.

$BL = L + \lambda$

where

$\lambda = \begin{cases} 12.5 + 0.45y & \text{(without transfer car)} \\ 29.5 + 0.45y & \text{(with transfer car)} \end{cases}$

$24 \leq y \leq 54$ inches.

Example:

Suppose AS/RS is to be designed for 40" x 48" (depth x width) unit loads that are 48" tall.

There are to be 8 aisles.

each aisle is 12 loads height and 80 loads long.

With sprinklers and no transfer car.

The minimum dimensions of the building:

$$BH = \frac{12(48+10)}{12} + \frac{48}{12} = 62 \text{ ft.}$$

$$BW = \frac{8(3)(40+6)}{12} + 2\text{ft} = 94 \text{ ft.}$$

$$BL = \frac{80(48+8)}{12} + 12.5\text{ft} + 0.45(48) = 407.43 \text{ ft.}$$

∴ A building of at least 62 ft tall, 94 ft wide, and 407.43 ft long will be required.

Rack Cost Calculation:

$$CRO = \alpha\left[0.92484 + 0.025v + 0.0004424w - (w^2/82{,}500{,}000) + 0.23328n - 0.00476n^2\right]$$

Example:

Suppose a storage rack is to be provided to accomodate 10.000 unit loads, weighing 2500 pounds and having a dimension of 42" x 48" + 46.5". Suppose the rack will support 10 unit loads vertically, (10 tiers of storage) If $\alpha = 30\$$, what will be the cost of the rack.

$x = 42"$, $y = 48"$, $z = 46.5"$, $w = 2500$ lb., $n = 10$

$\alpha = \$30.$ $\quad v = \dfrac{42 \times 48 \times 46.5}{1728} = 54.25 \text{ ft}^3.$

$$CRO = 30\left[0.92484 + 0.025 * 54.25 + 0.0004424 * 2500 - (2500^2/82.500.000) + 0.23328 * 10 - 0.00476\ 10^2\right]$$

$= \$155.0442$ per rack opening

$\therefore$ 10.000 x \$155.0442 = \$1,550,442 # approximately

S/R Machine Cost Calculation

CSR = A + B + C (the cost per S/R machine)

- A: based on the height of the system
- B: based on the weight of the system
- C: based on the type of the machine control.

H	A
$H < 35'$	β
$35' \leq H < 50'$	2β
$50' \leq H < 75'$	3β
$75' \leq H < 110'$	4β
$H \geq 110'$	5β

W	B
$W < 1000$ lb	γ
$1000 \leq W < 3500$	2γ
$3500 \leq W < 6500$	3γ
$W \geq 6500$	4γ

Control logic	C
manual	ϕ
on-board	2ϕ
end-of-aisle	3ϕ
central console	4ϕ

Example: Suppose six S/R machines to be used to lift 2500 lb loads to a height of 55 ft and central console is to be used to control the S/R machine.

Based on current market prices, $\beta = \phi = \gamma = \$25.000$

$H = 55$ ft, $W = 2500$ lb

$$CSR = 3\beta + 2\gamma + 4\phi = 9 * (25.000) = \$225.000$$

per S/R machine

Building Cost Calculation:

$$BC = (BW)(BL)(CF)\,\delta$$

BH	CF
25'	1.00
40'	1.25
55'	1.50
70'	1.80
85'	2.50

Example:

Suppose a 60 ft-tall building is to be used to house an AS/R System. Assuming it costs $\$30/ft^2$ to construct a 25-in-tall building. Suppose the footprint of the building is 150 ft x 440 ft. What will be the cost of the building.

By interpolation CF is obtained to be 1.633.

$$BC = 150\,(440)(1.633) \cdot 30 = \$3{,}234.000.$$

Example:

Suppose storage space of 1.540.000 ft^3 must be provided.
A 55 ft tall building will yield a footprint of 28.000 ft^2.

$$BC = 1,5(28.000)\cdot\$ = 42.000\,\$.$$

If a 25 ft-tall building is built, 61.600 ft^2 of footprint is required.

$$BC = 1,0(61.600)\cdot\$ = 61.600\,\$$$

If 70 ft-tall building.

$$BC = 41.800\,\$$$ ⇐ minimum cost obtained at a lenght of 70 ft.

If 85 ft-tall building

$$BC = 45.294\,\$$$