

台86線

24號橋地震災損橋梁復建 及耐震補強工程



交通部公路總局
第五區養護工程處

車載試驗分析

督導單位：交通部公路總局第五區養護工程處
承 包 商：國家地震工程研究中心
監造單位：第五區養護工程處新化工務段
協助單位：台灣世曦工程顧問股份有限公司

主講者：陳彥豪

中華民國 105 年 06 月 20 日



台灣世曦工程顧問股份有限公司
CECI Engineering Consultants, Inc., Taiwan



簡報內容

- 一、前言
- 二、24號橋車載試驗分析
- 三、24號橋車載試驗規劃
- 四、結論與建議
- 五、討論

前言



預力構件檢測重點

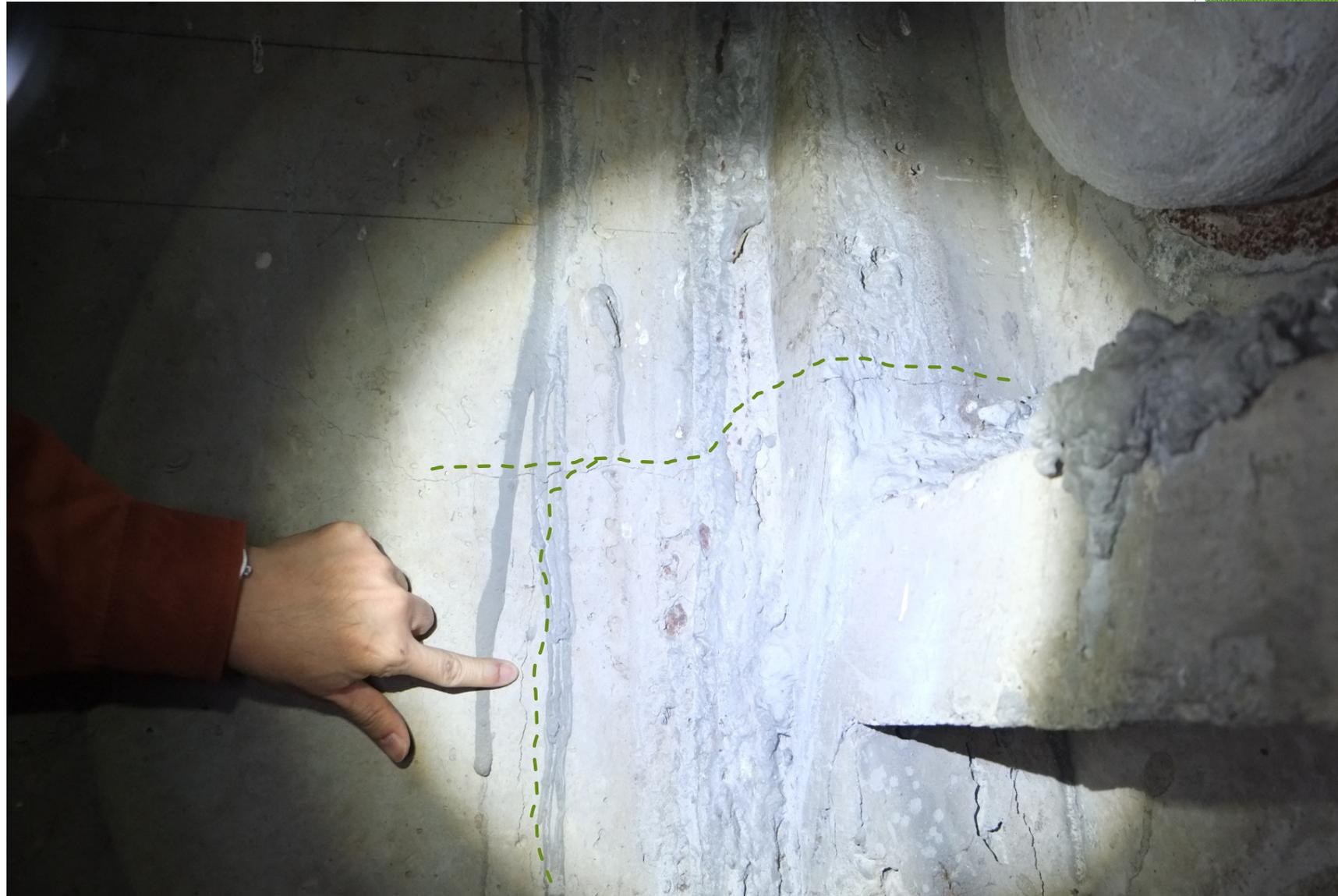
目視檢測

1. 大梁變形
2. 混凝土裂縫、剝落
3. 預力端錨裝置
4. 錨碇座混凝土裂縫
5. 外置斜索套管裂縫及破損
6. 外置斜索預力端錨座

特殊儀器檢測

1. 射線探測套管空隙
2. 套管內視鏡
3. 十字弓法纜索預力檢測
4. 切槽法預力量測
5. 鋼筋及鋼腱腐蝕電位量測
6. 載重試驗變形驗證

預力端錨座裂縫檢視



預力端錨座裂縫檢視



箱梁內裂縫檢視

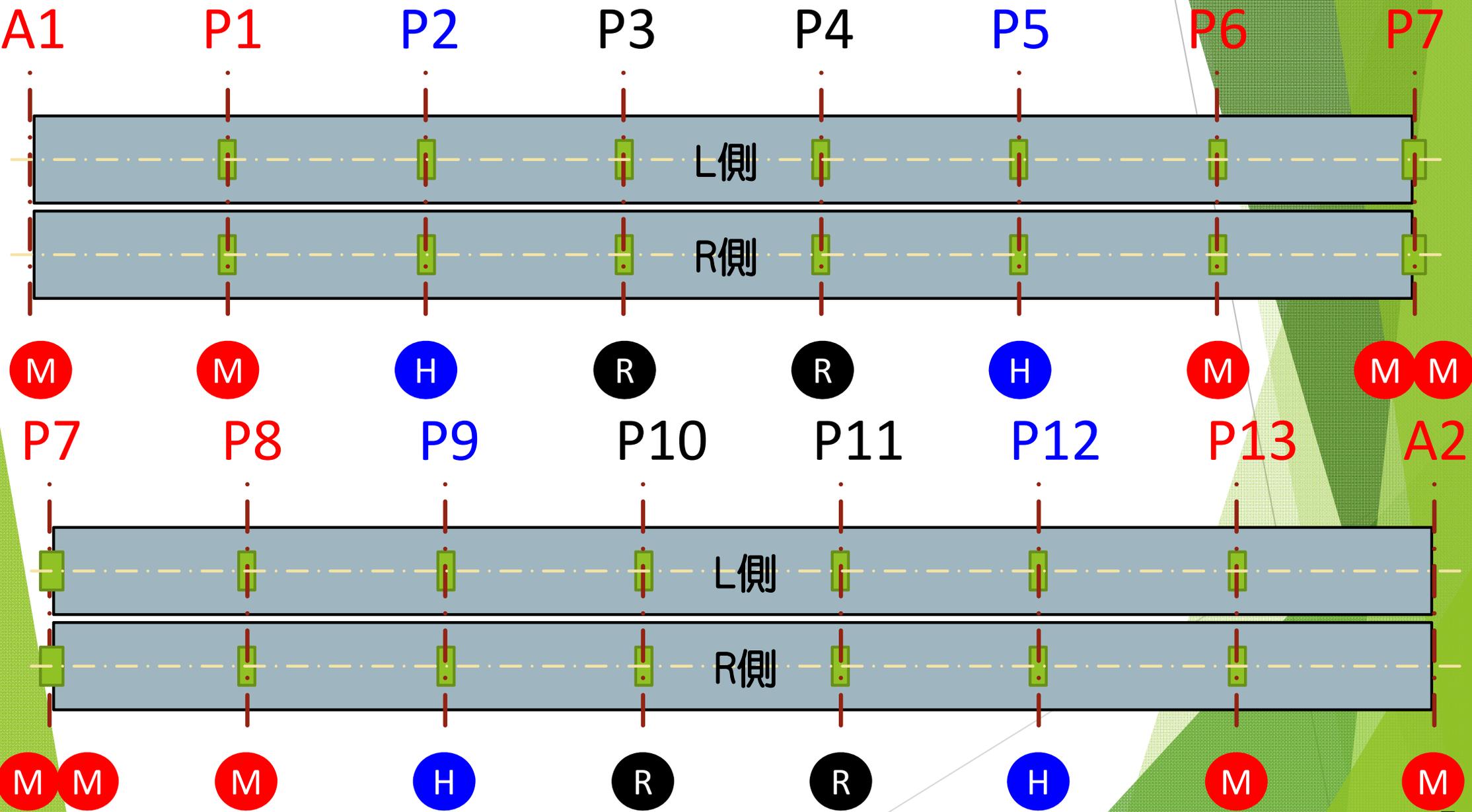


箱梁內檢測通風設備及氧氣瓶

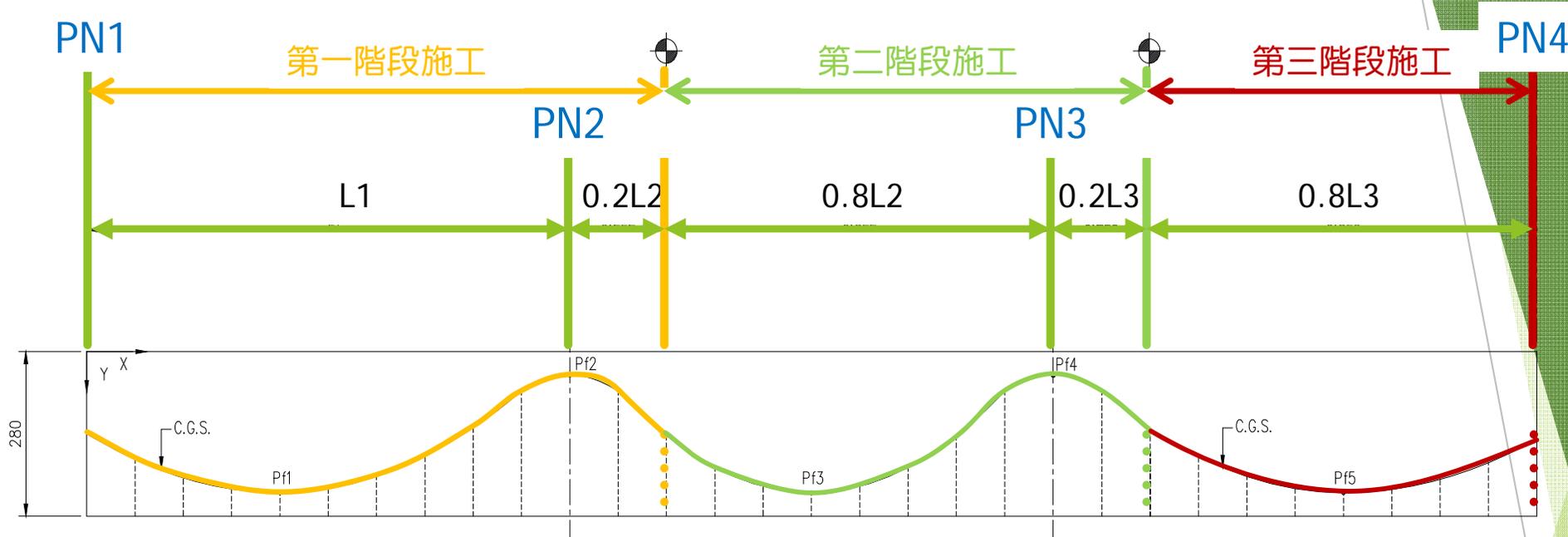


2016.02.15 14:47

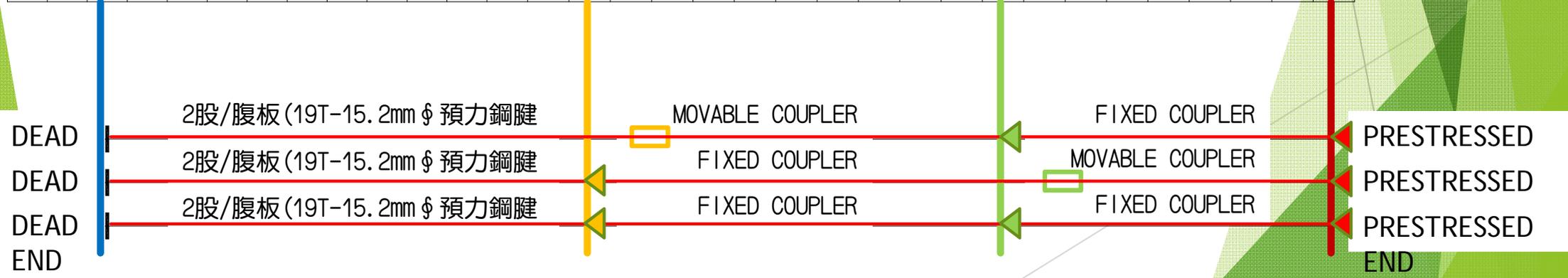
24號橋為分別為2個7跨連續的逐跨架設工法橋梁。
 橋總長為555m。民國85年完成設計，88年竣工。



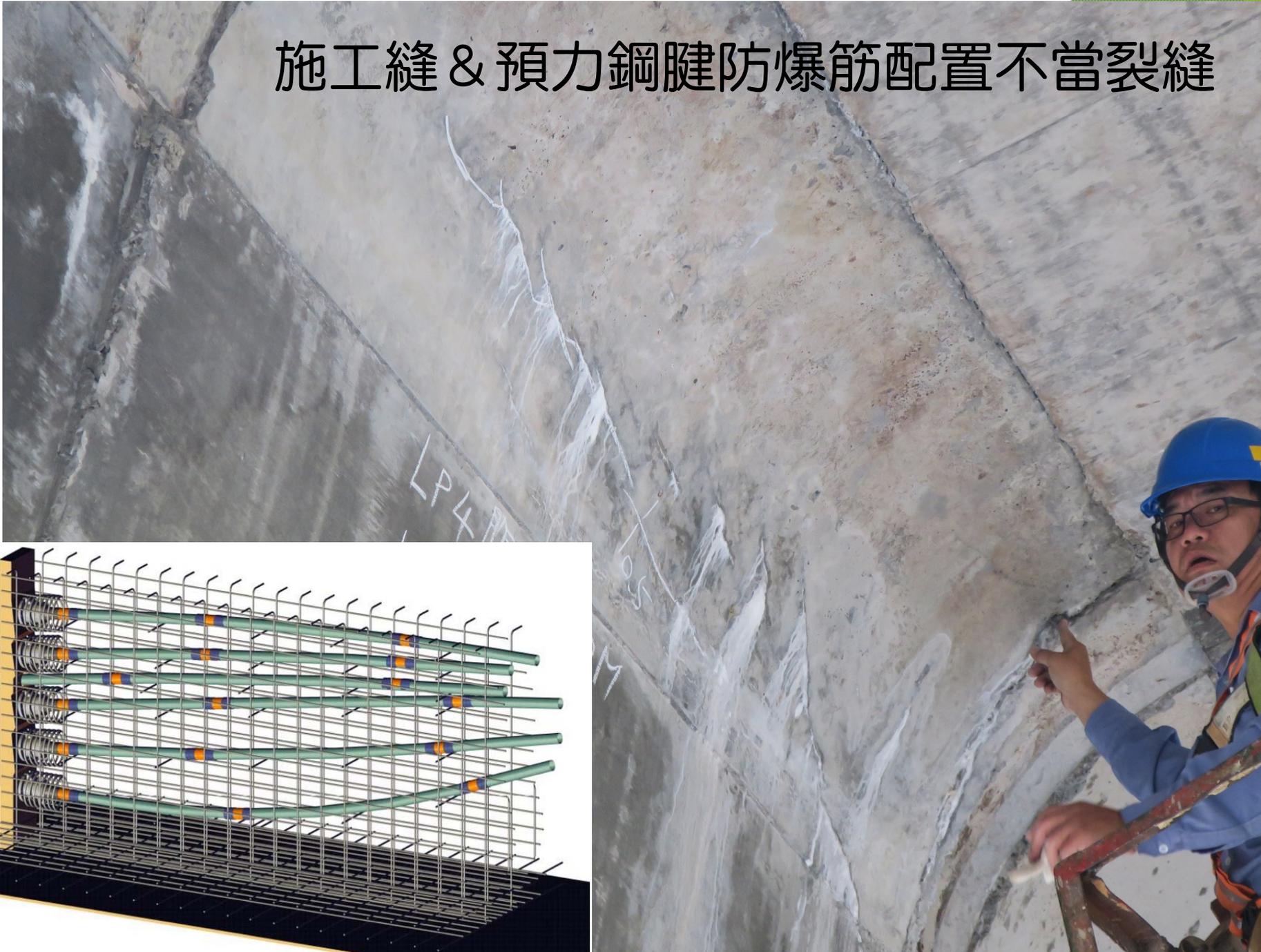
逐跨架設工法介紹



| | | | | | | | | | | | | | | | | | | | |
|----------|-----|--|-------|--|--|--|------------|-------|--|-------|--|--|--|------------|-------|--|-------|--|-----|
| X(cm) | 0 | | 0.4L1 | | | | L1 0.00 | 0.2L2 | | 0.5L2 | | | | L2 0.00 | 0.2L3 | | 0.6L3 | | L3 |
| T1 Y(cm) | 140 | | 240 | | | | 50 | 154.5 | | 240 | | | | 50 | 138.7 | | 240 | | 140 |



施工縫 & 預力鋼腱防爆筋配置不當裂縫



※本圖擷取自阿爾格工程有限公司網頁



施工縫 & 預力鋼腱防爆筋配置不當裂縫



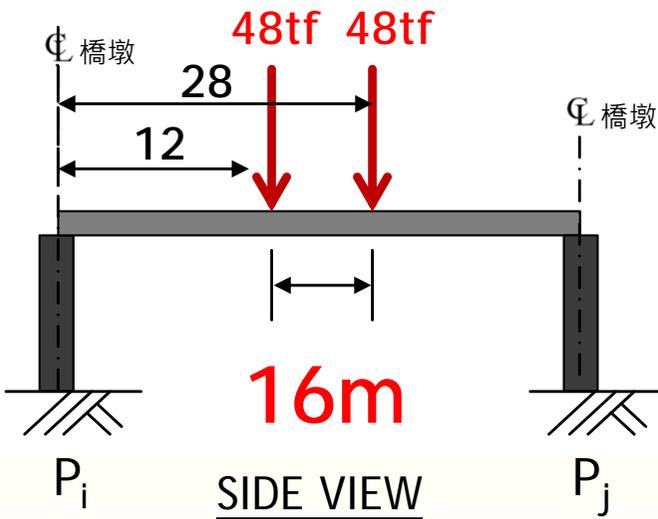
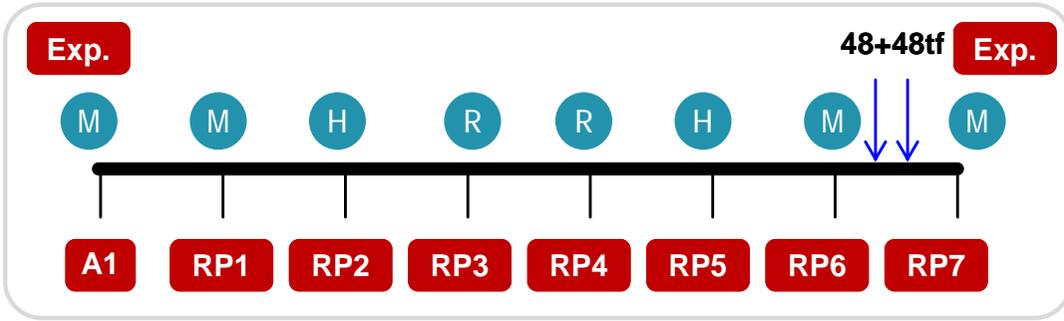
箱梁內頂板表面溫度裂縫

24號橋車載試驗分析

- HS20-44 車道活載重：
計算最大彎矩：均佈載重 = 0.96 tf/m，集中載重 = 8.2 tf
- 活載重超載 = 30%
- 衝擊係數 $I = 15.24 / (L + 38.1)$

| | |
|----------------------------|--|
| RU1單元(A1-RP7) 橋跨 L(M) | 40 |
| 衝擊係數 I= | 0.195 |
| 單車道活載重 $LL * (1+I)$ (tonf) | $(0.96 * 40 + 8.2) * (1.195) = 55.687$ |
| 橋淨寬 (M) | 11.4 |
| 車道數 (line) | 2 |
| 規範車道數載重之折減 | 1.0 |
| 活載重超載加乘(Impact) = 30% | 1.30 |
| 橋跨：總活載重(1+Impact) (tonf) | 144.7862 |
| 一部卡車重Total (Tonf) | - |
| 需求卡車數 | 4(6)部 24tf |
| 需求卡車數(整數) | 96 tf → $96 / 144.7862 = 66.3\%$ 144 tf → $144 / 144.7862 = 99.5\%$ |

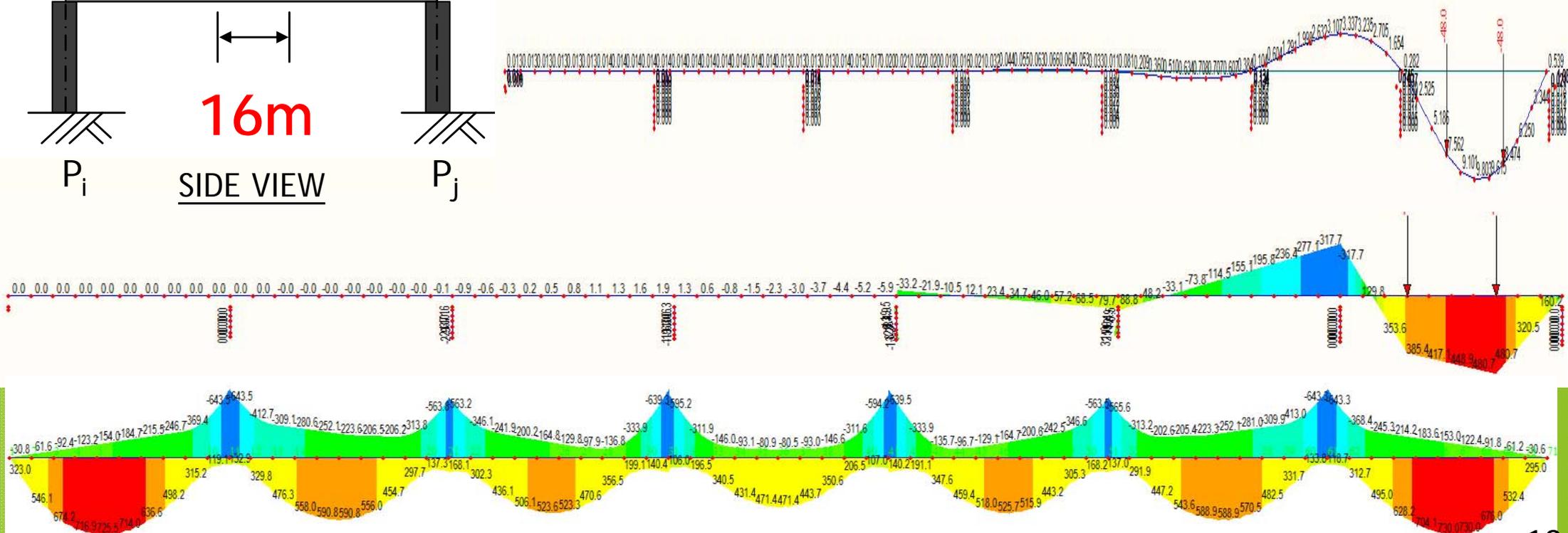
Case 1



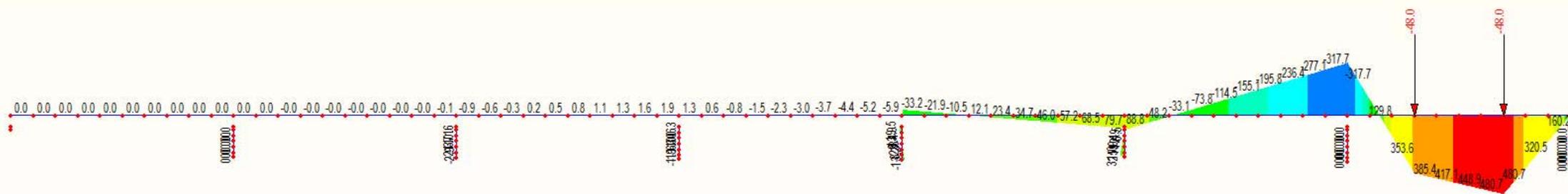
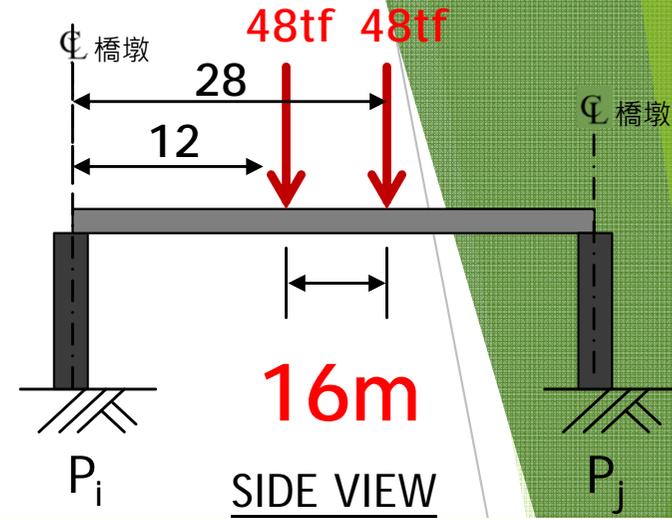
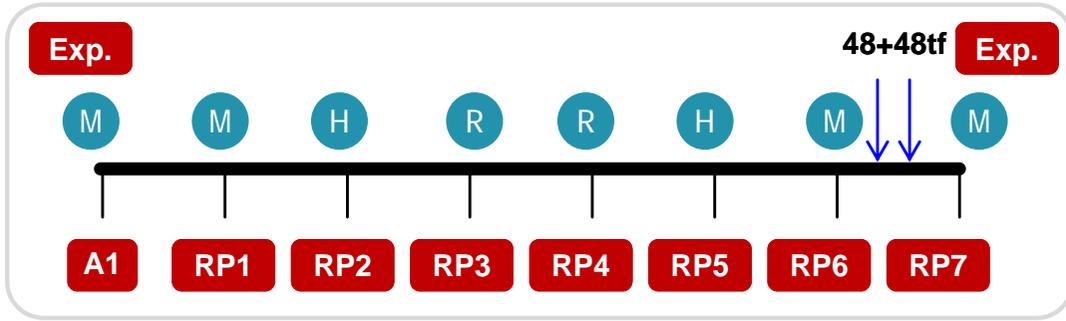
Case 1 - 彎矩比較 (tf-m)

| 跨徑位置 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|---------|---------|---------|
| Case 1 | | | 480.7 |
| 規範活載 | | | 730.0 |
| 百分比 | | | 65.8 % |

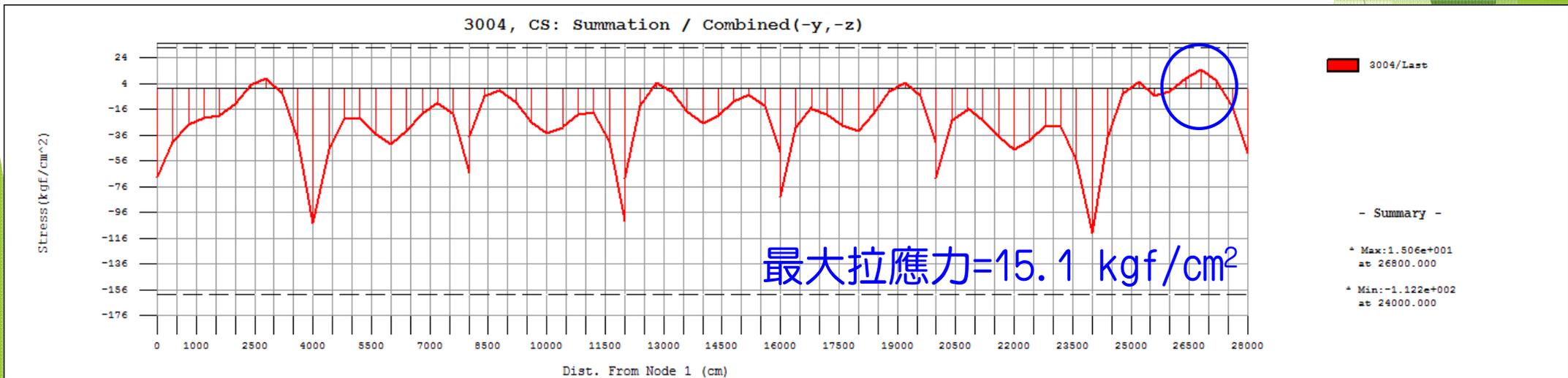
最大變形 = 9.8 mm



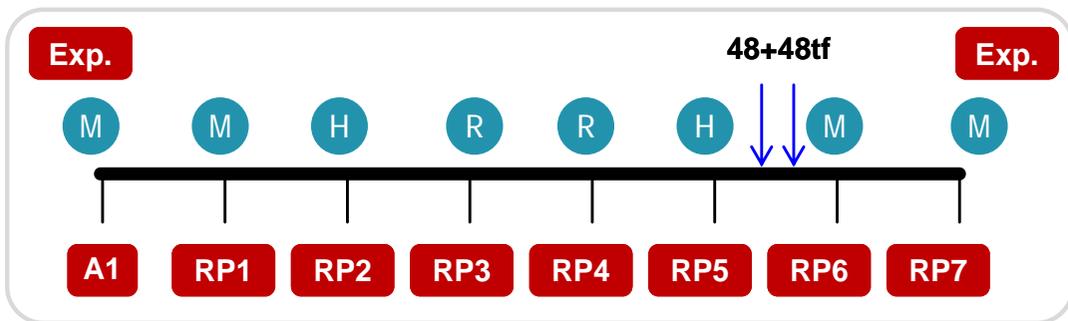
Case 1



Case 1 主梁底板應力圖

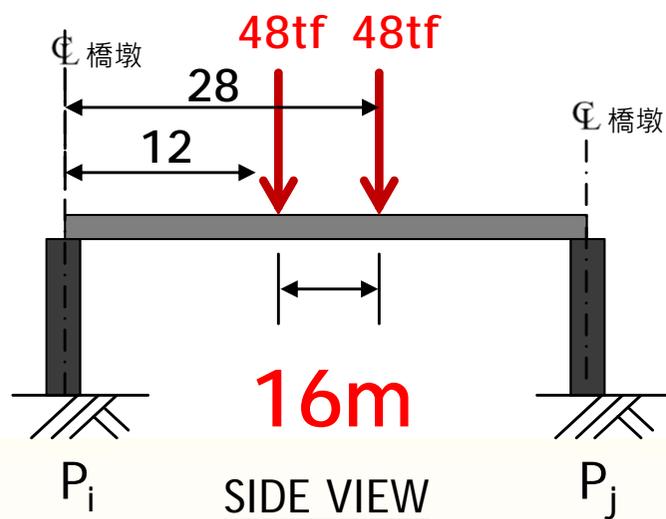


Case 2

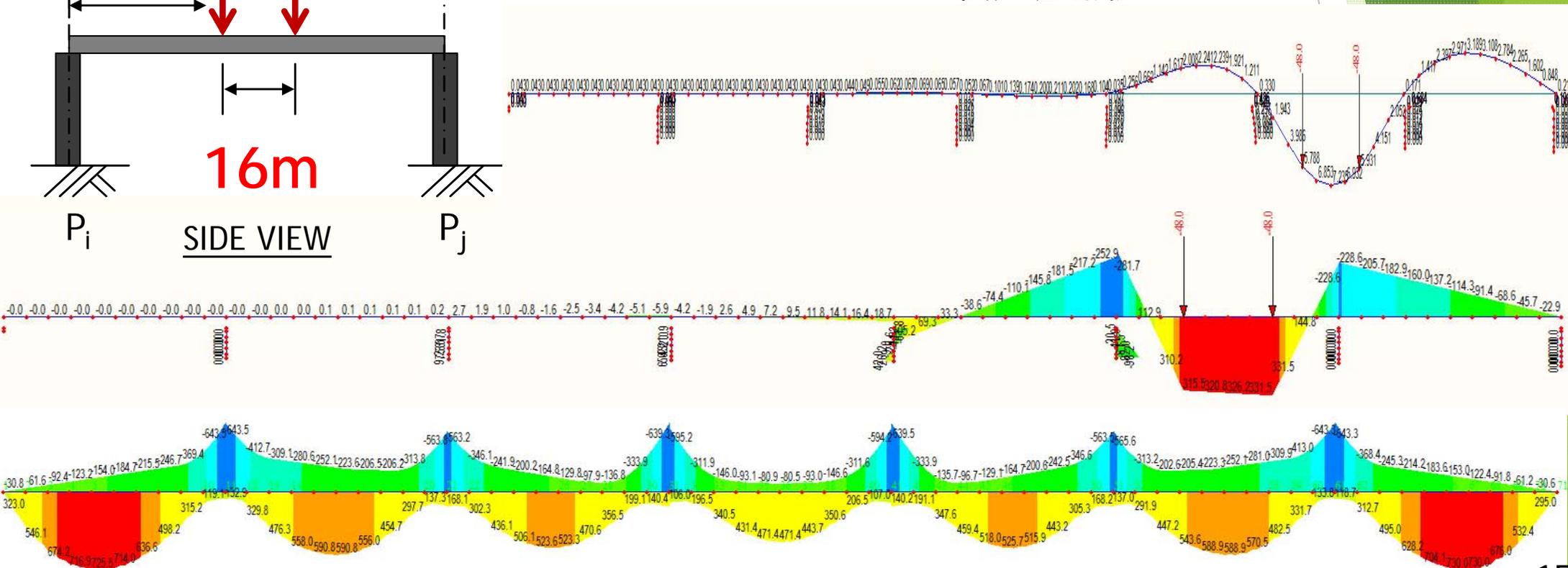


Case 2 - 彎矩比較 (tf-m)

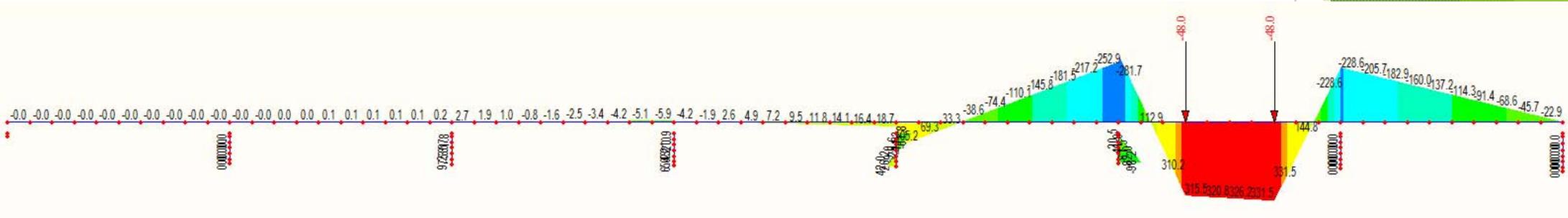
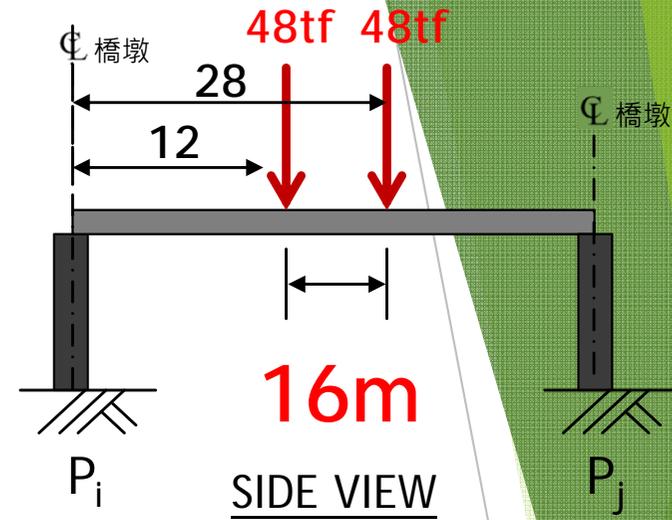
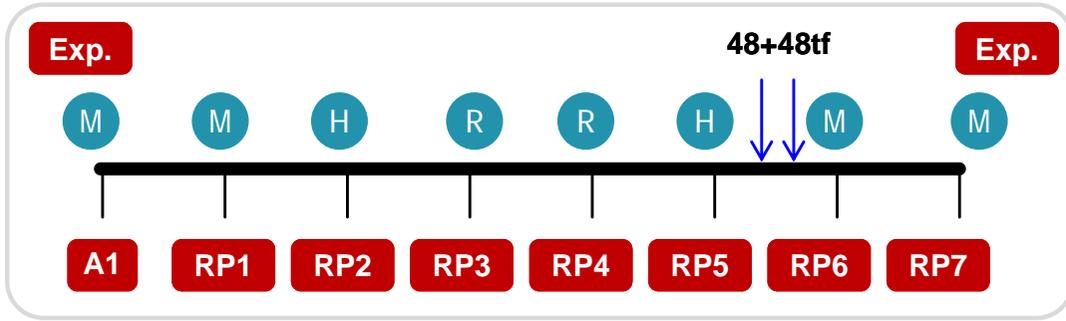
| 跨徑位置 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|---------|---------|---------|
| Case 2 | | 311.5 | |
| 規範活載 | | 588.9 | |
| 百分比 | | 52.9% | |



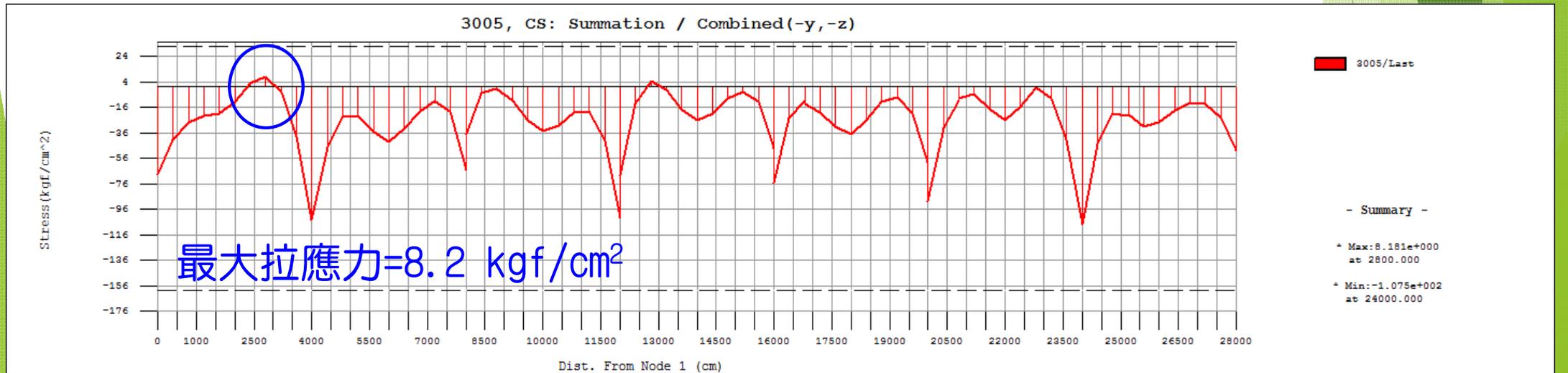
最大變形=7.2mm



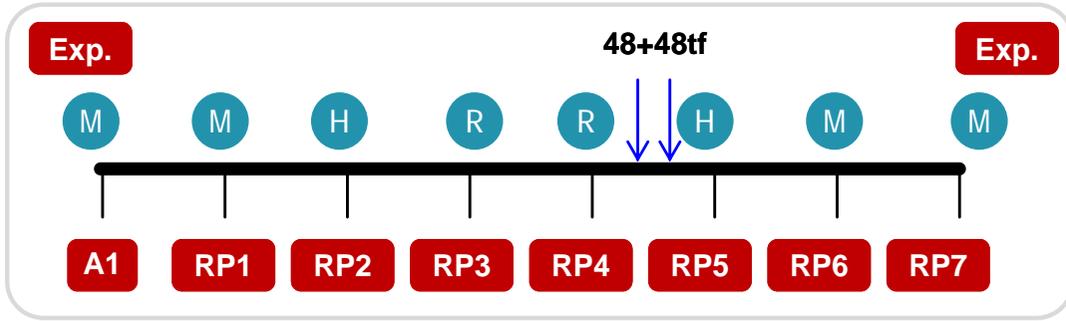
Case 2



Case 2 主梁底板應力圖

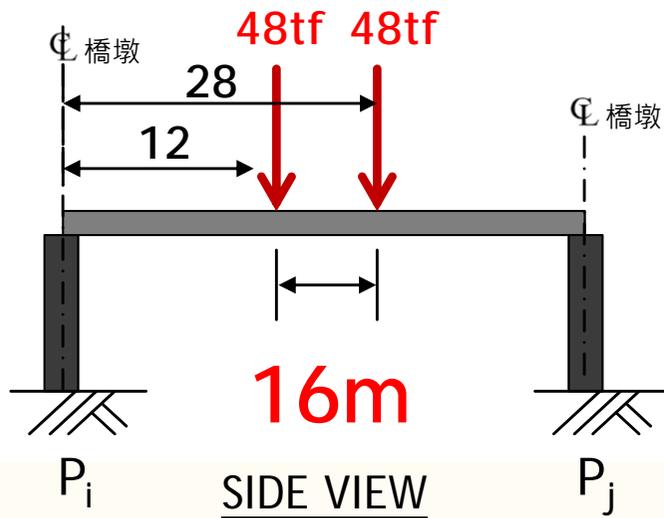


Case 3

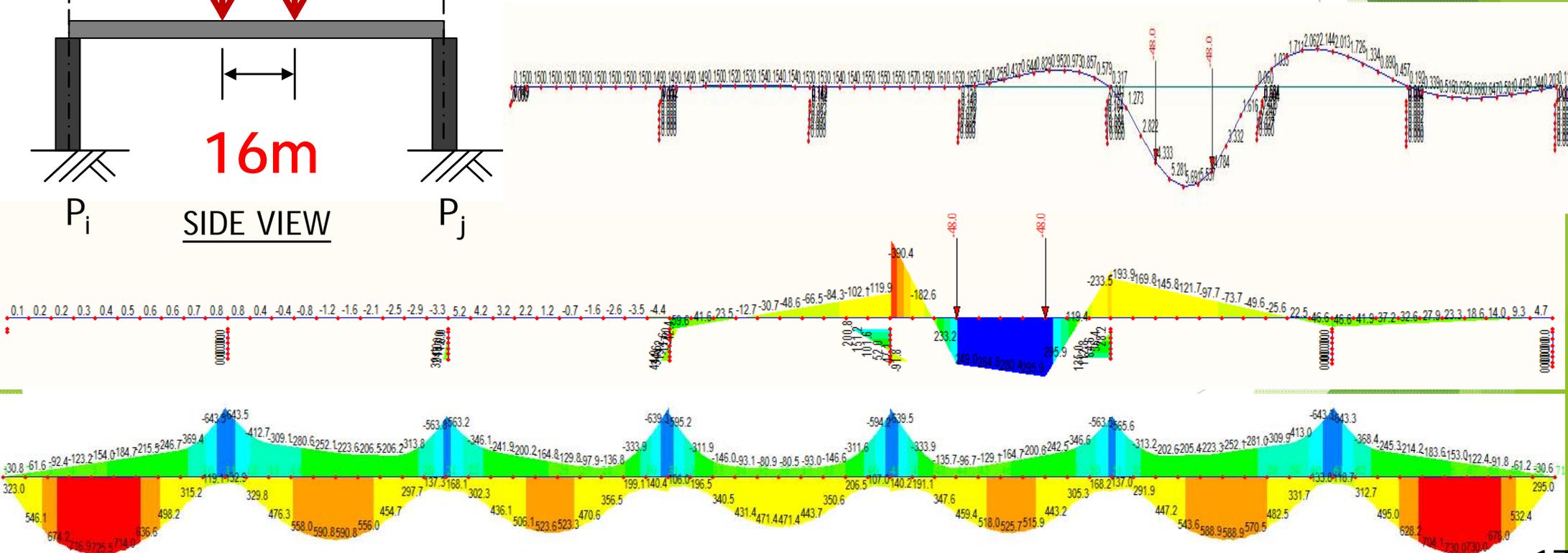


Case 3 - 彎矩比較 (tf-m)

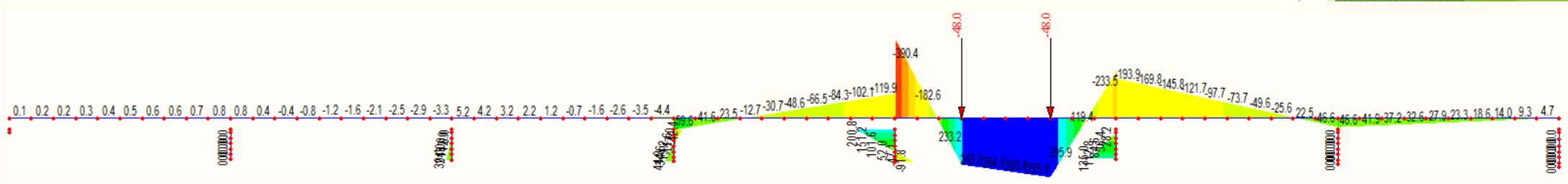
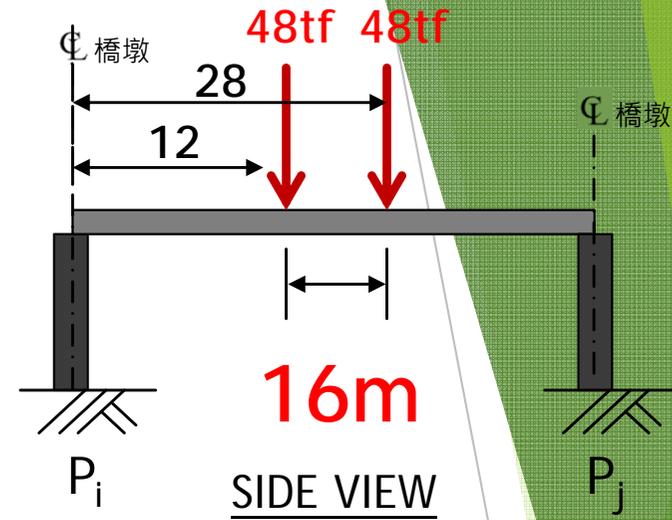
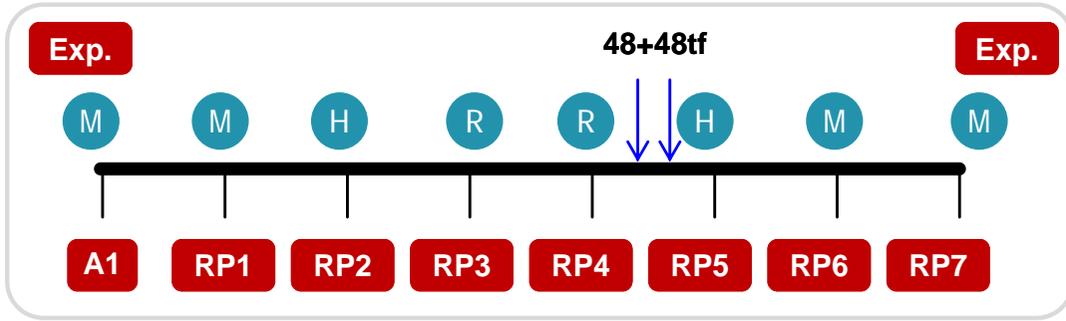
| 跨徑位置 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|---------|---------|---------|
| Case 3 | 295.9 | | |
| 規範活載 | 525.7 | | |
| 百分比 | 56.3% | | |



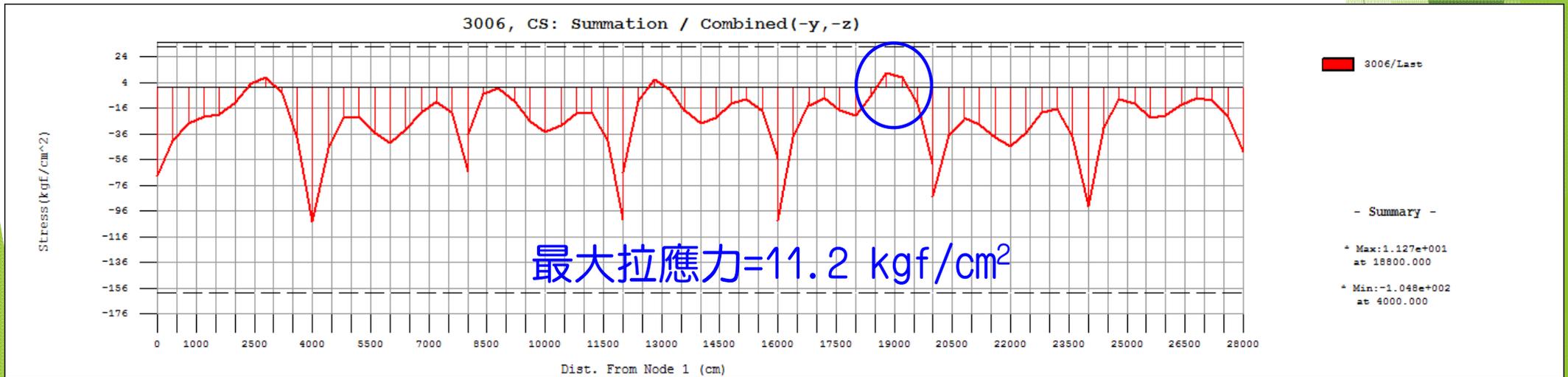
最大變形 = 5.7 mm



Case 3

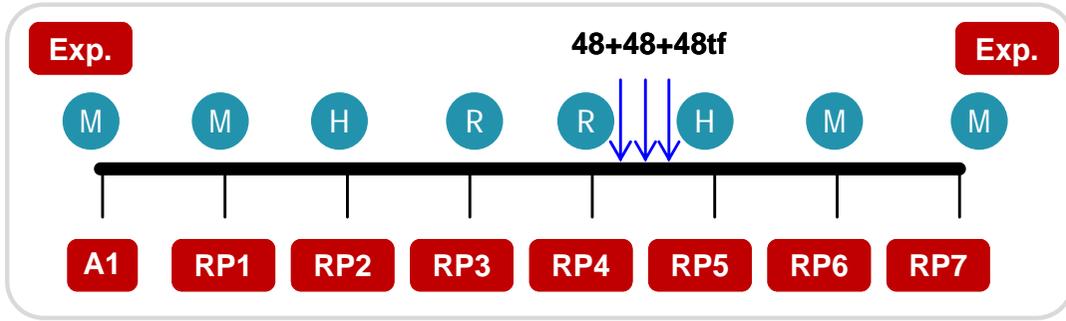


Case 3 主梁底板應力圖

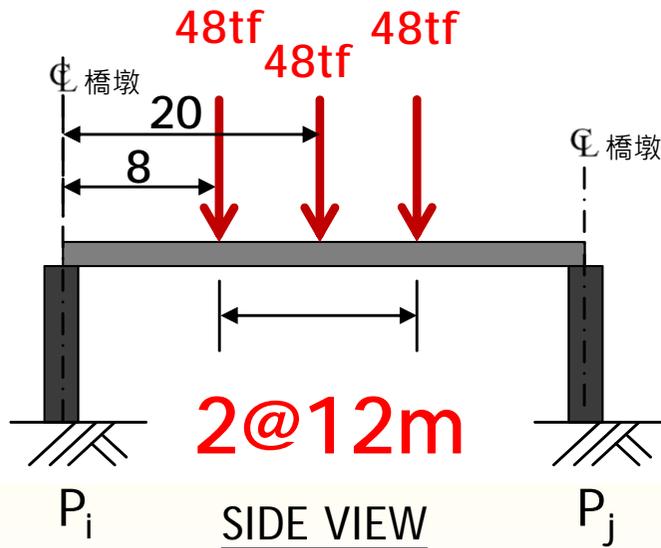


Case 4

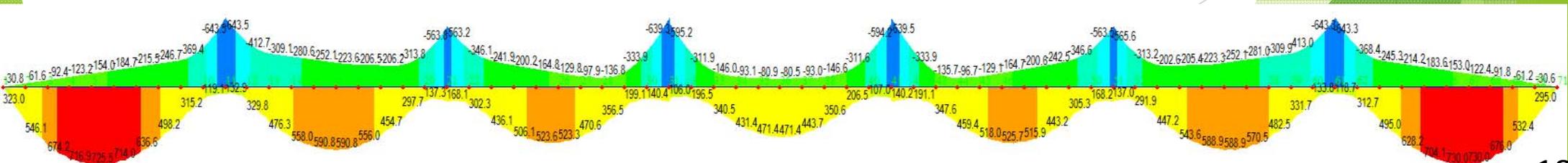
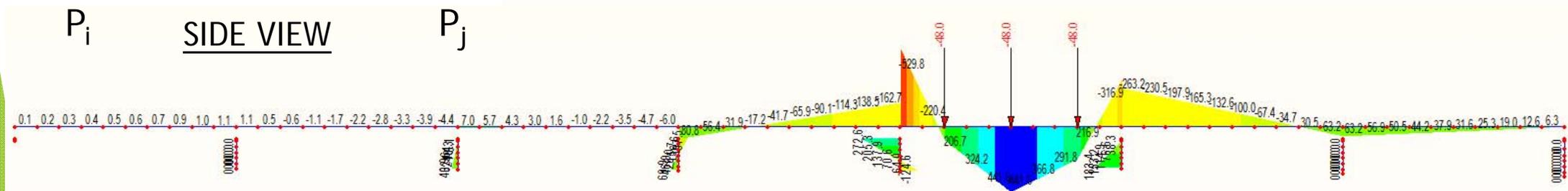
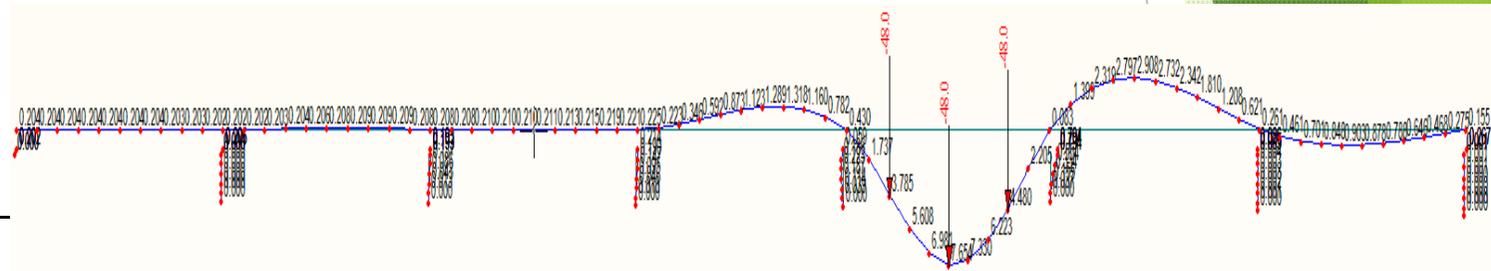
Case 4 - 彎矩比較 (tf-m)



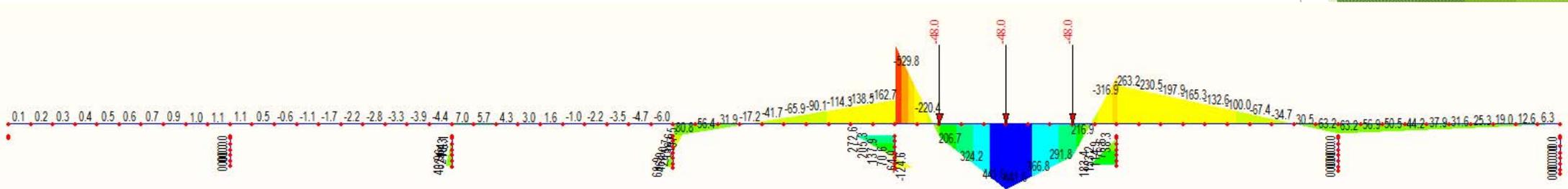
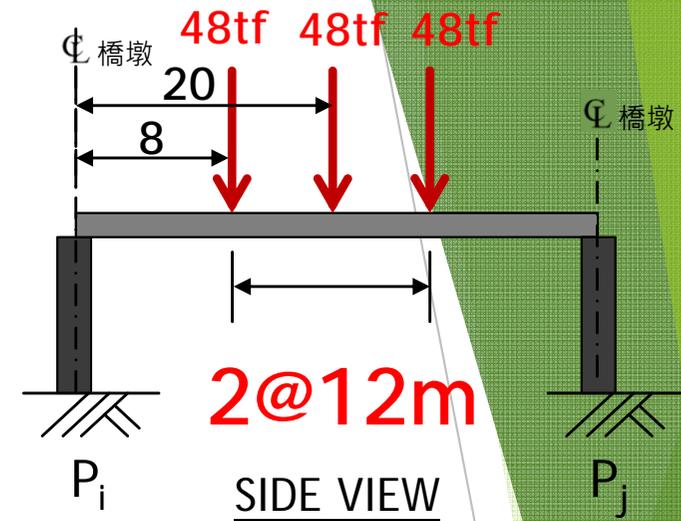
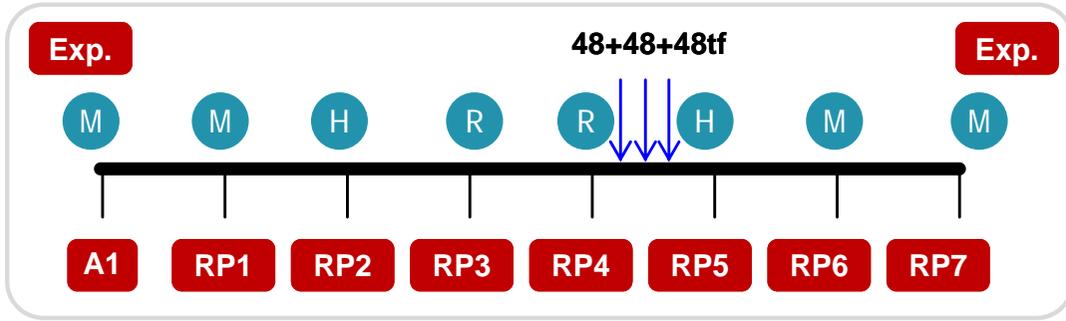
| 跨徑位置 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|---------|---------|---------|
| Case 4 | 441.6 | | |
| 規範活載 | 525.7 | | |
| 百分比 | 84.0% | | |



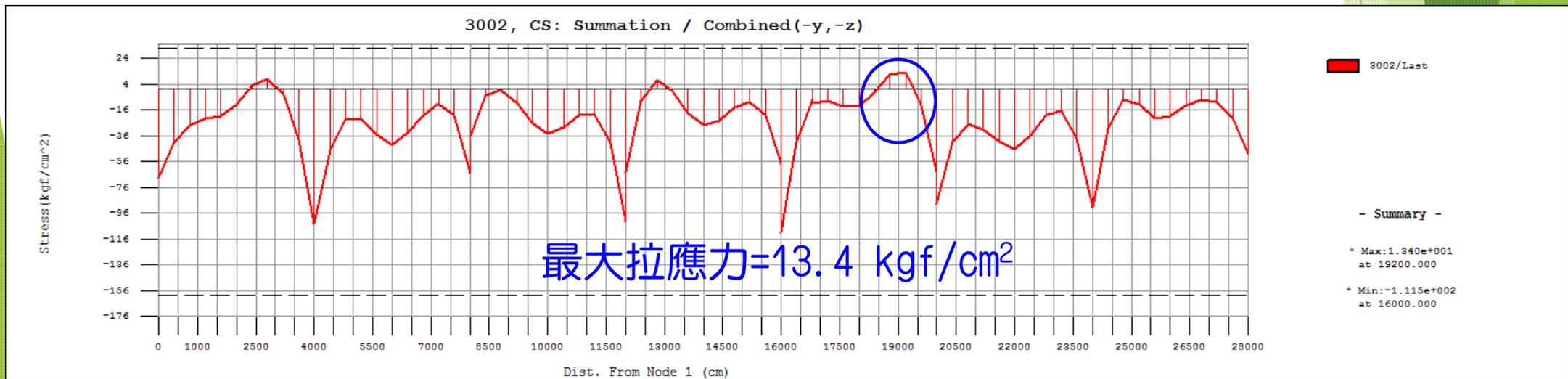
最大變形 = 7.7 mm



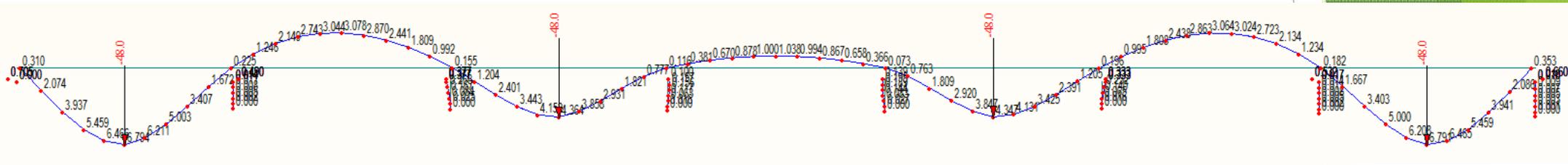
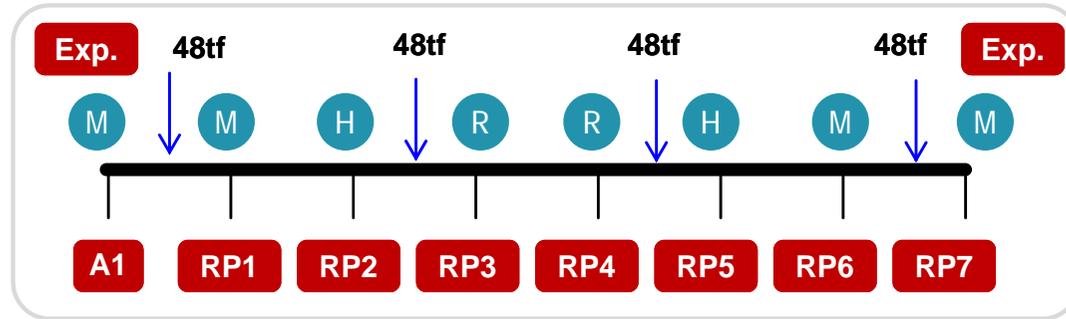
Case 4



Case 4 主梁底板應力圖



Case 5

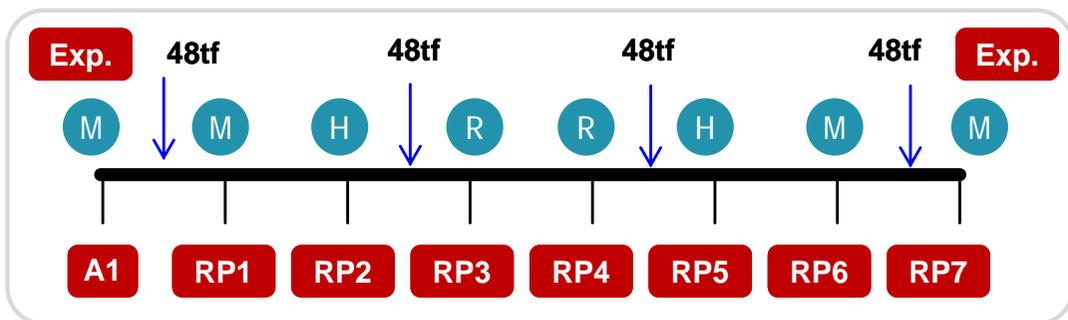


最大垂直變形量 (mm)

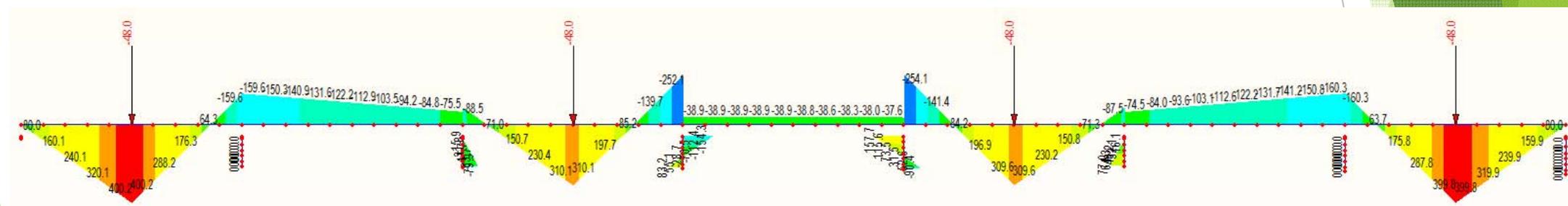
| 跨徑位置 | A1~RP1 | RP1~RP2 | RP2~RP3 | RP3~RP4 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|--------|---------|---------|---------|---------|---------|---------|
| Case 5 | -6.8 | +3.1 | -4.4 | +1.0 | -4.3 | +3.1 | -6.8 |

Case 5

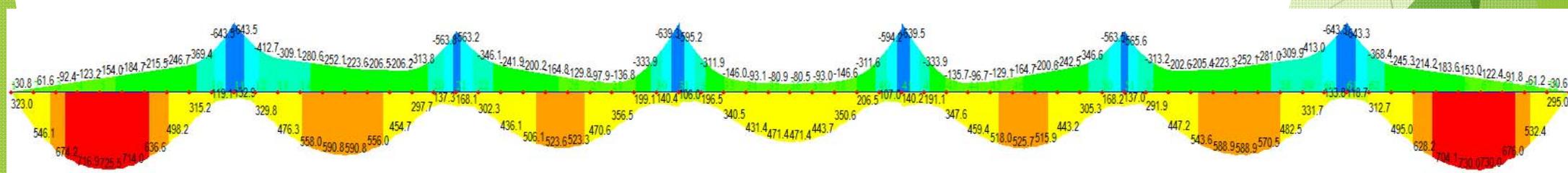
彎矩比較 (tf-m)



| 跨徑位置 | A1~RP1 | RP1~RP2 | RP2~RP3 | RP3~RP4 | RP4~RP5 | RP5~RP6 | RP6~RP7 |
|--------|--------|---------|---------|---------|---------|---------|---------|
| Case 5 | 400.2 | 122.2 | 310.1 | 38.9 | 309.6 | 122.2 | 399.8 |
| 規範活載 | 725.5 | 590.8 | 523.6 | 471.1 | 525.7 | 588.9 | 730 |
| 百分比 | 55.2% | 20.7% | 59.2% | 8.3% | 58.9% | 20.8% | 54.8% |



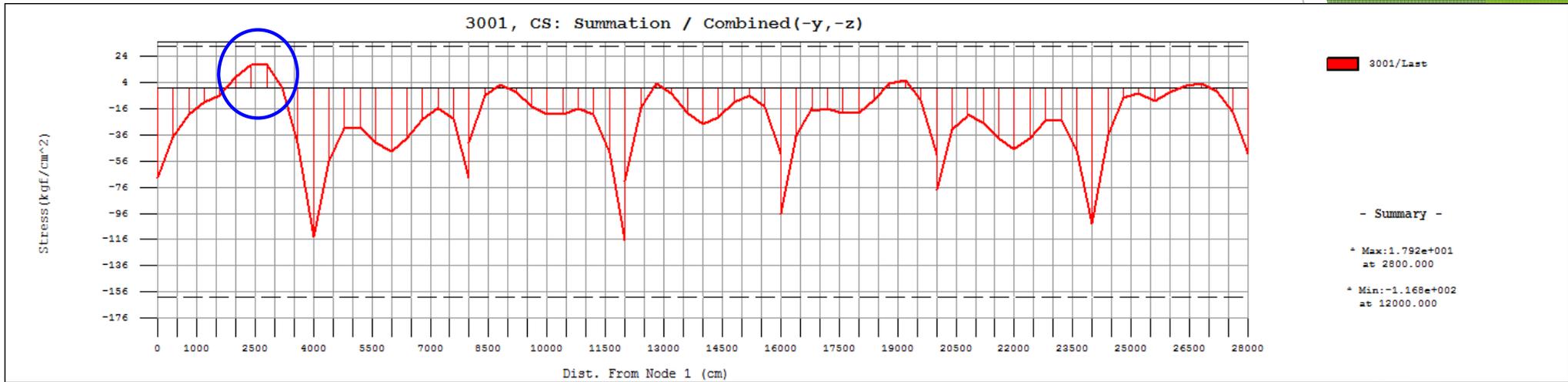
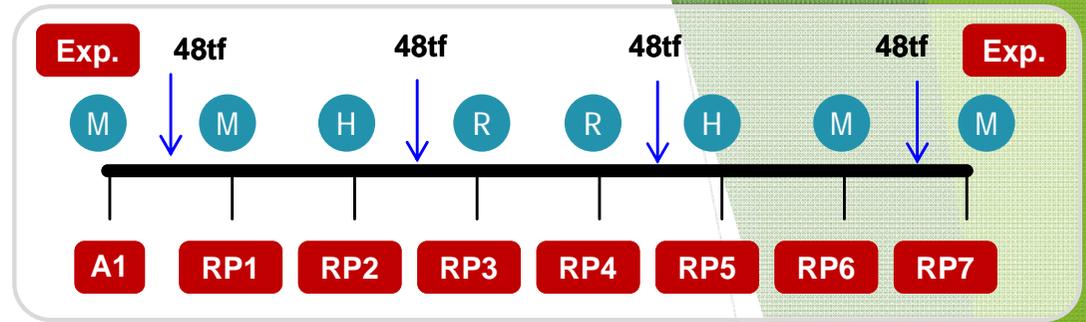
Case 5 主梁彎矩圖



規範活載-主梁彎矩圖

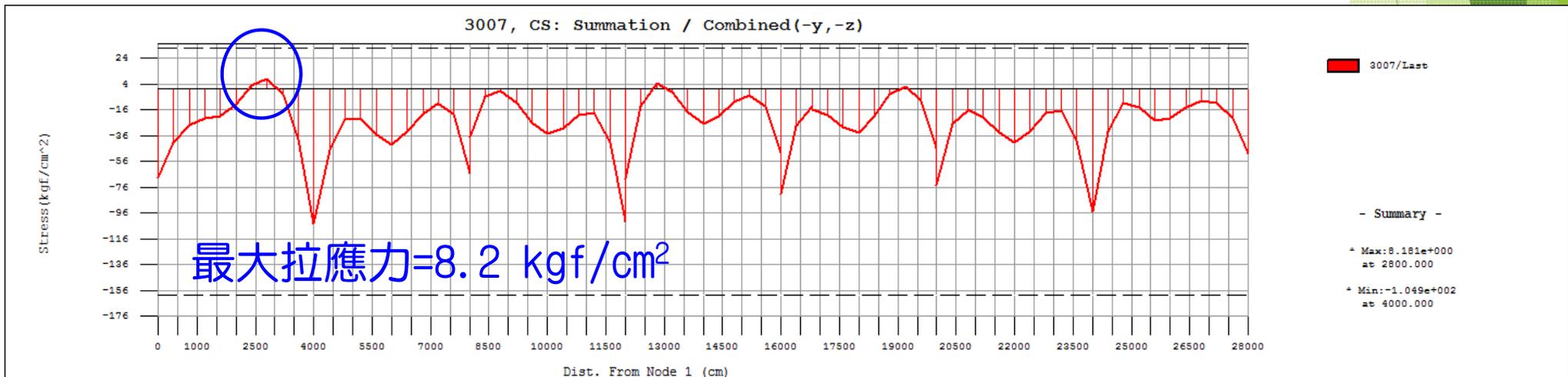
Case 5 主梁底板應力圖

最大拉應力=17.9 kgf/cm²

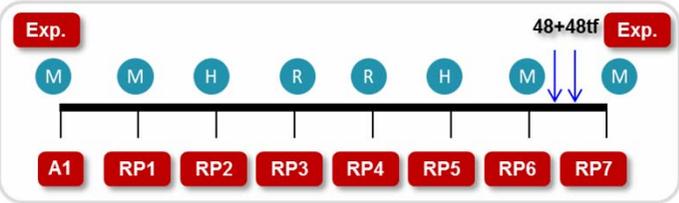
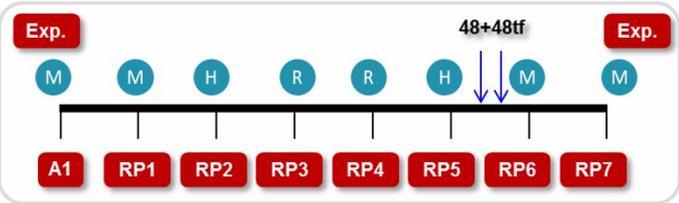
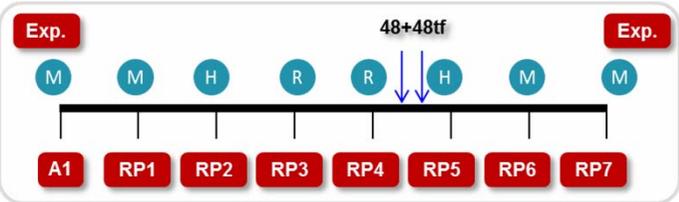
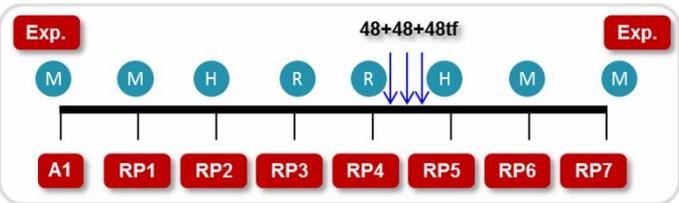
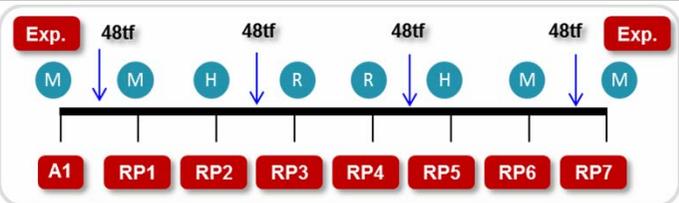


卸載後-主梁底板應力圖

最大拉應力=8.2 kgf/cm²



總比較表

| 車載擺法 | 圖形示意 | 車載重 | 車載比 (規範, %) | Δ_{\max} (mm) | M_{\max} (規範比, %) | $\sigma_{T\max}$ (kgf/cm ²) |
|---------|--|--------------------|----------------|-------------------------|------------------------|--|
| PR6~RP7 |  | 96 tf (車距12 m) | 66.3 | 9.8 | 65.8 | 15.1 |
| PR5~RP6 |  | | 66.3 | 7.2 | 52.9 | 8.2 |
| PR4~RP5 |  | | 66.3 | 5.7 | 56.3 | 11.2 |
| PR4~RP5 |  | 144 tf (車距12 m) | 99.5 | 7.7 | 84.0 | 13.4 |
| 棋盤式 |  | 各 48 tf | 33.2 | 6.8 | 59.2 | 17.9 |



5/18試驗時程規劃

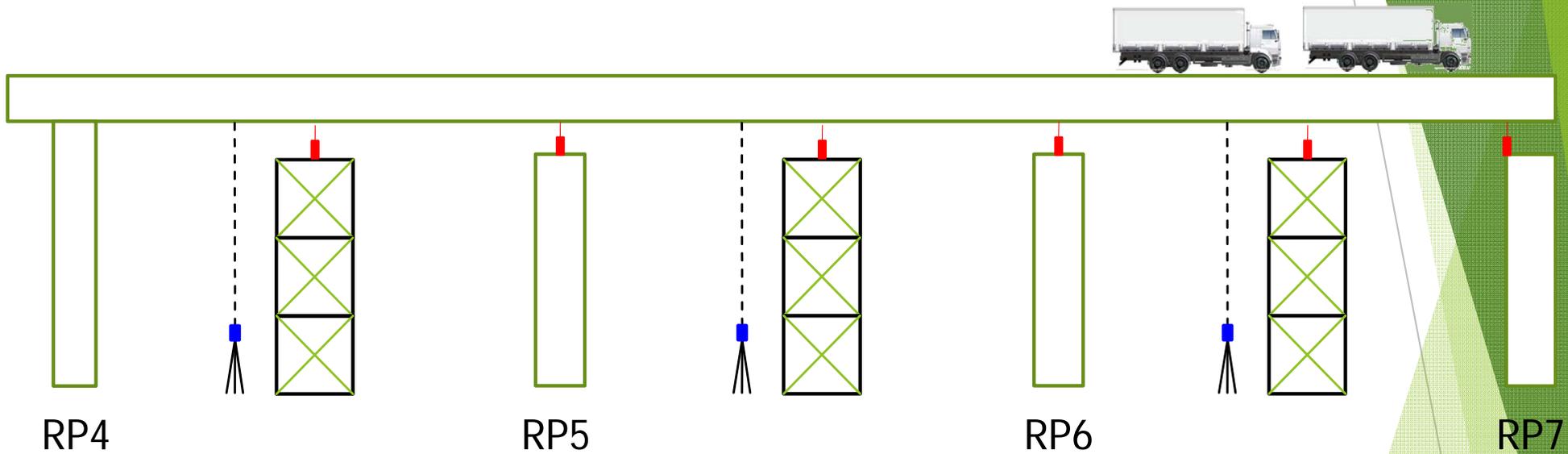
- ▶ 上午 4-5時：全橋初始狀態
- ▶ 上午 9-12時：A1單元
 - ▶ 靜態載重試驗 x 4 組
 - ▶ 動態載重試驗 x 6 組
- ▶ 下午 13-17時：A2單元
 - ▶ 靜態載重試驗 x 4 組
 - ▶ 動態載重試驗 x 6 組

動態載重試驗目的

1. 等速試驗：瞭解結構物的動態放大行為
2. 煞車試驗：瞭解結構物的阻尼比

A1單元位移計配置

(A2單元採相同配置)



千分儀 X 6
雷射測距儀 X 3

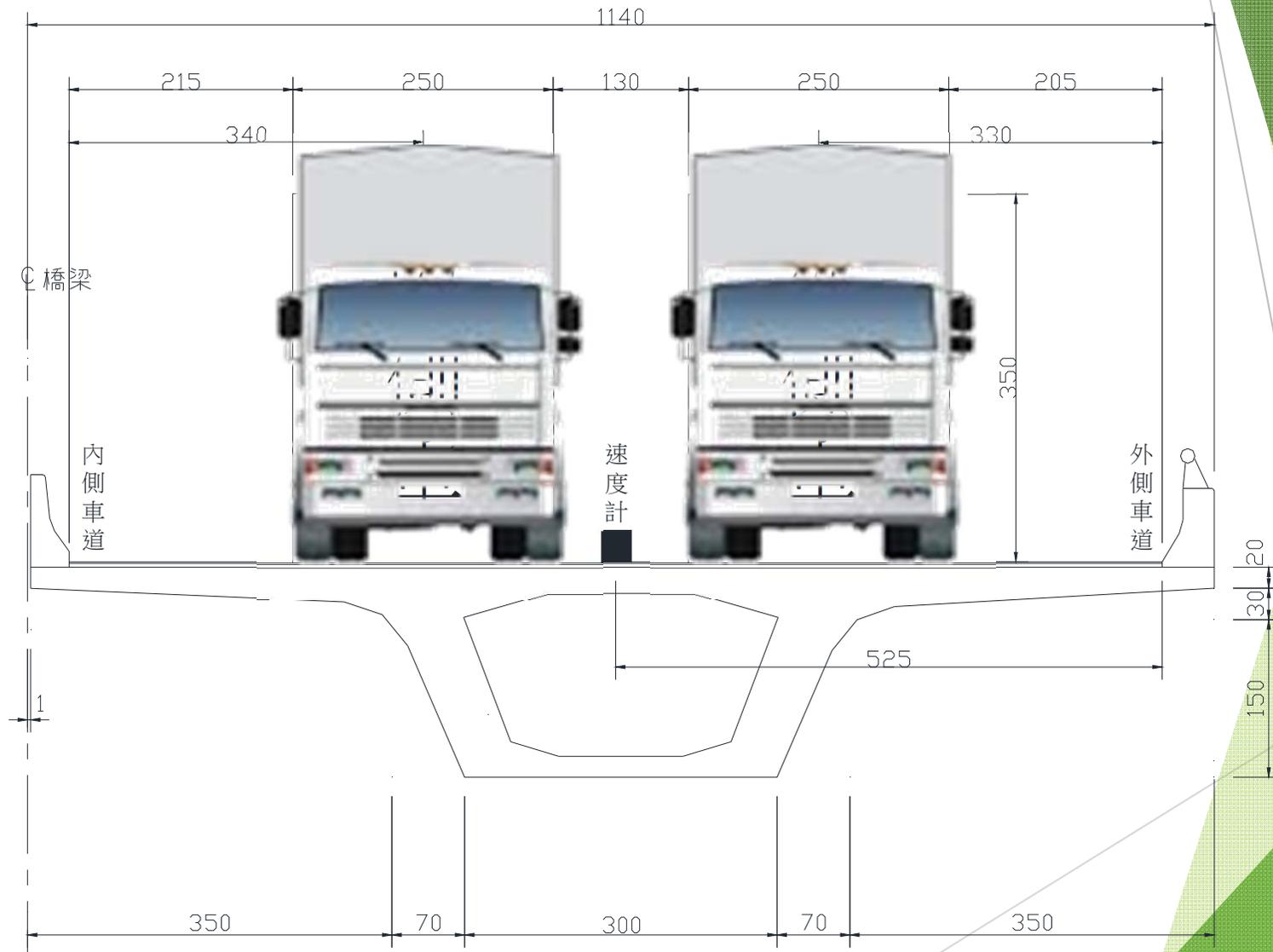


千分儀精度高(量測精度±0.01mm)

雷射測距儀精度差 (量測精度 $\pm 1.0\text{mm}$)

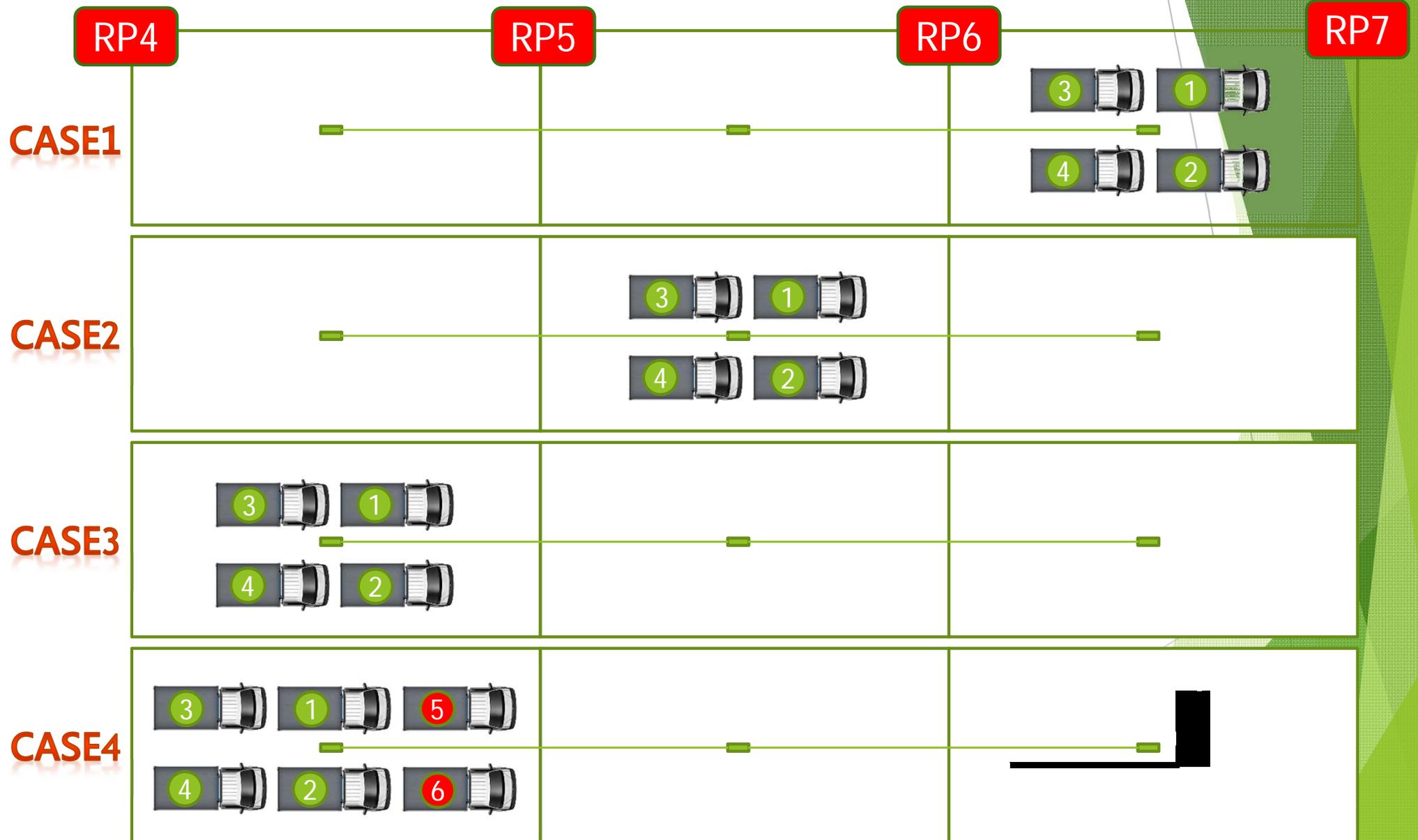


靜態試驗車輛配置剖面圖

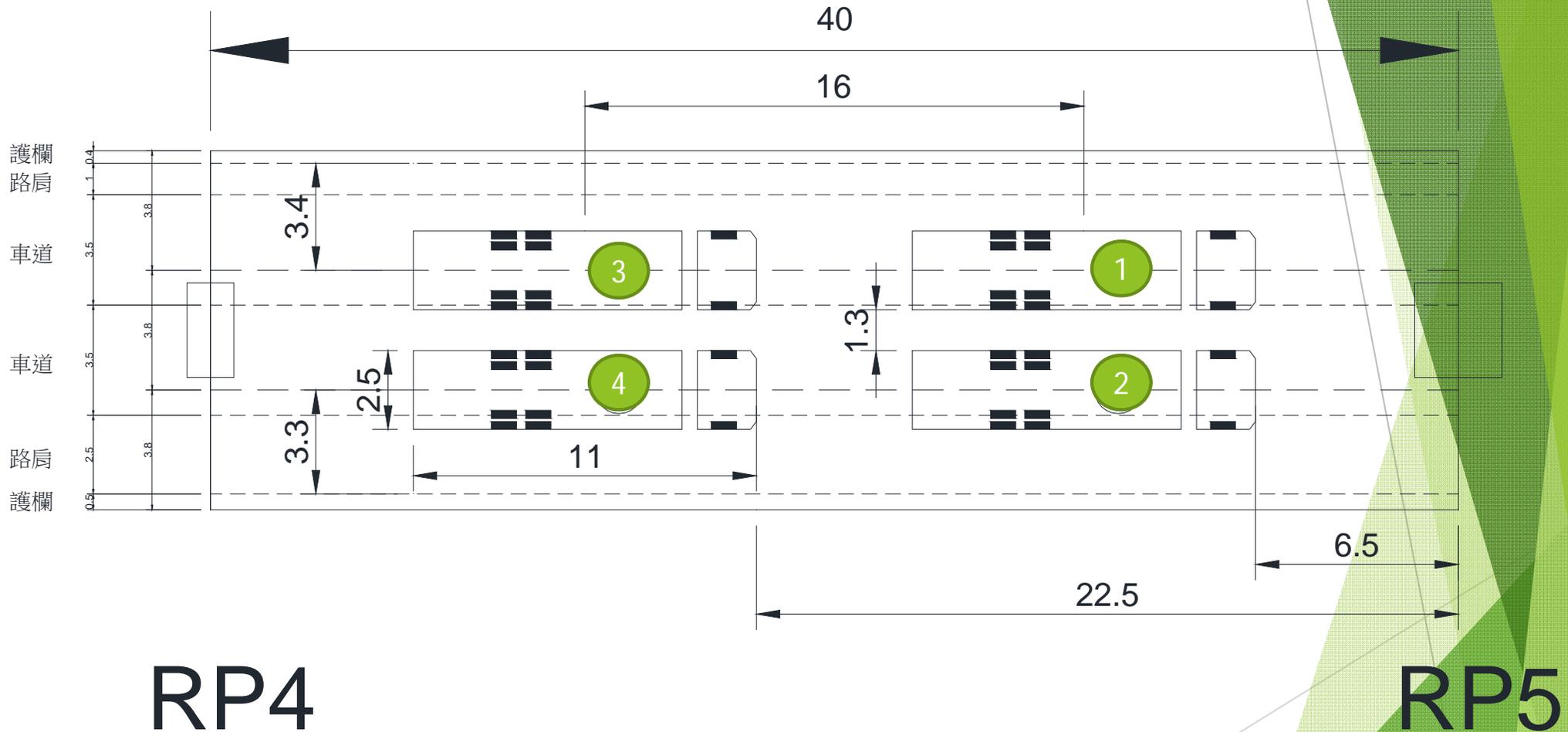


靜態載重試驗

A1單元靜態試驗車輛配置

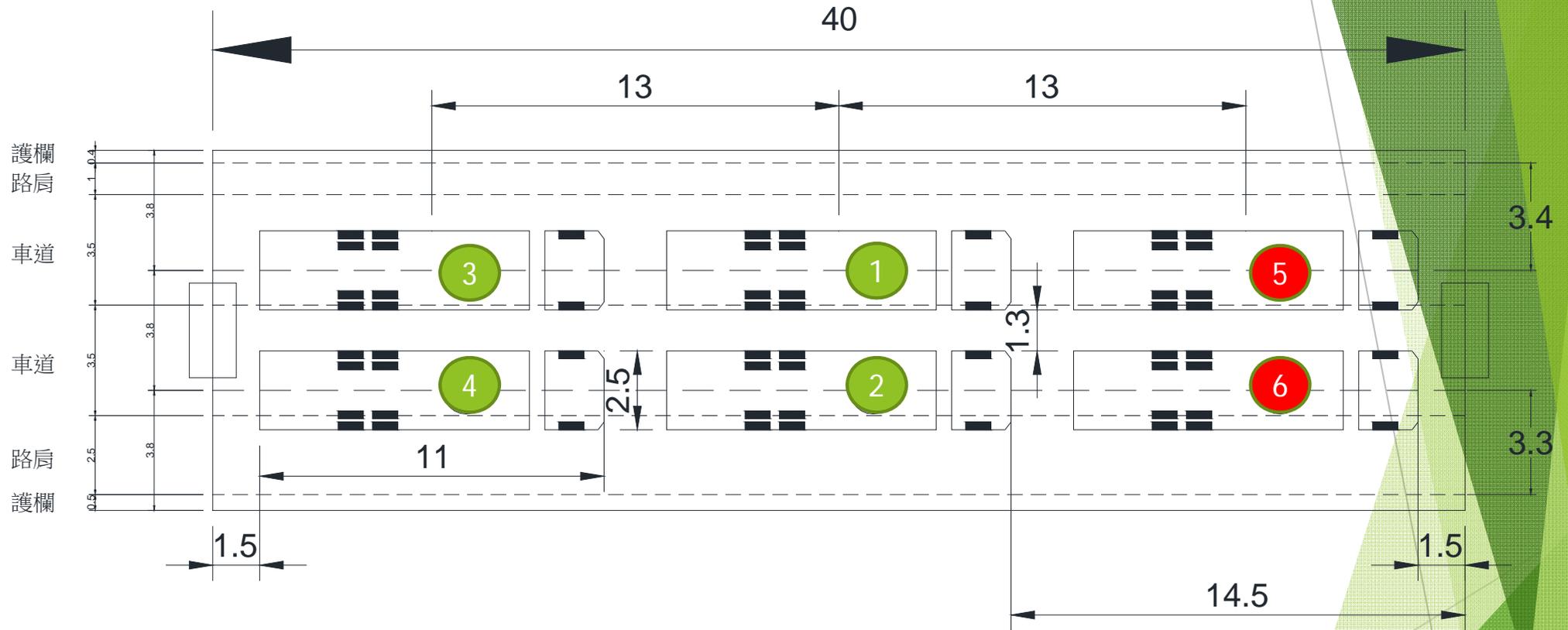


A1單元CASE3車輛配置



A1單元：CASE3

A1單元CASE4車輛配置



RP4

RP5

A1單元：CASE4

變位預測結果

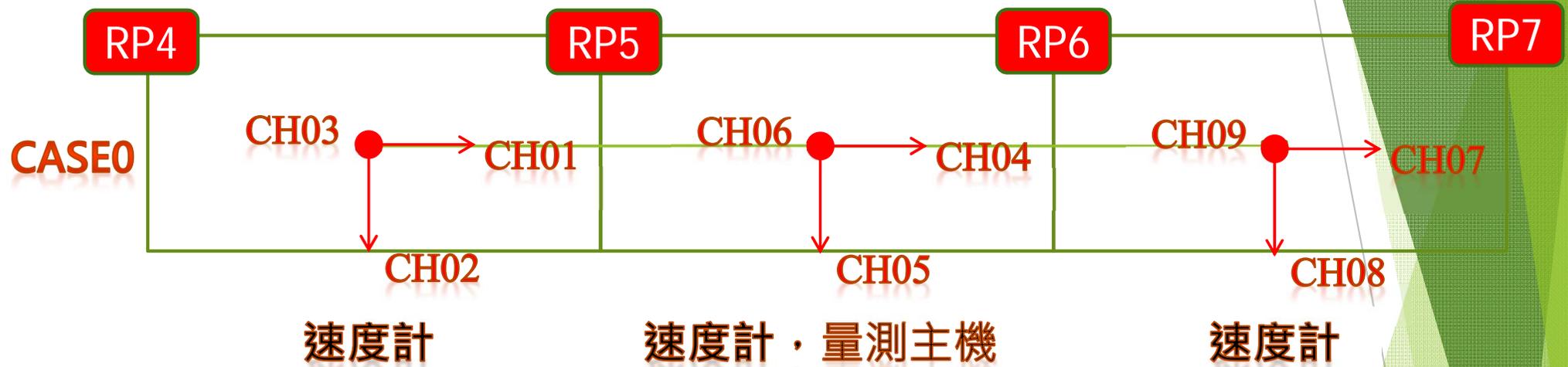
| 車載擺法 | 圖形示意 | 車載重 | $\Delta_{\max}(\text{mm})$ (EI) | $\Delta_{\max}(\text{mm})$ (0.5EI) |
|---------|------|--------------------|------------------------------------|---------------------------------------|
| PR6~RP7 | | 96 tf (車距16 m) | 9.80 | 19.55 |
| PR5~RP6 | | | 7.24 | 14.20 |
| PR4~RP5 | | | 5.69 | 10.44 |
| PR4~RP5 | | 144 tf (車距13 m) | 7.13 | 13.05 |

變位實測結果比較

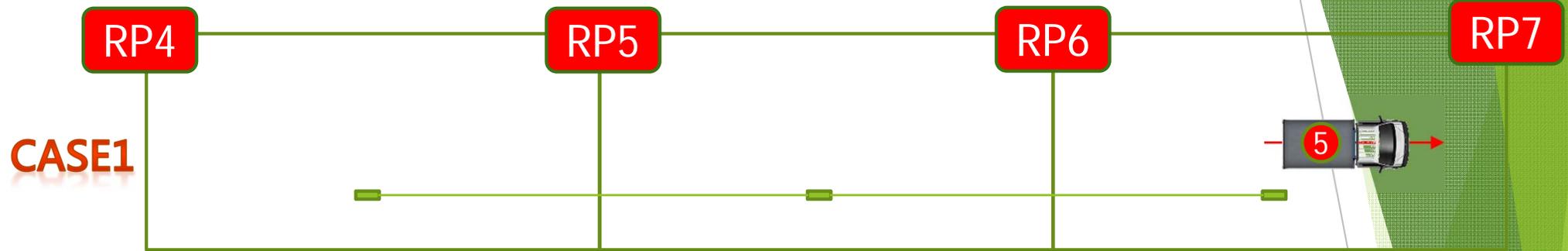
表 4 靜態載重試驗大梁中點位移值

| Unit | Case | Span | Car(s) | Displacement (mm) | | | | 分析值(mm) |
|------|------|----------|---------|-------------------|---------|----------|----------|---------|
| | | | | 18-May | | | 19-May | |
| | | | | Laser | LVDT | | LVDT | |
| | | | | Maximum | Maximum | Residual | Residual | |
| A1 | 1 | RP6-RP7 | 1 | - | 1.60 | 0.00 | - | 9.80 |
| | | | 2 | - | 3.40 | 0.00 | - | |
| | | | 3 | - | 5.20 | 0.00 | - | |
| | | | 4 | 7.00 | 7.00 | 0.00 | 0.00 | |
| A1 | 2 | RP5-RP6 | 4 | 7.00 | 6.40 | 0.00 | 0.16 | 7.24 |
| | 3 | RP4-RP5 | 4 | - | 5.48 | 0.00 | - | 5.69 |
| | 4 | RP4-RP5 | 6 | 7.00 | 7.90 | 0.80 | 0.48 | 7.13 |
| | A2 | 1 | RP7-RP8 | 4 | 7.00 | 7.92 | 0.16 | 0.32 |
| 2 | | RP8-RP9 | 4 | 7.00 | 6.72 | 0.08 | 0.00 | 7.24 |
| 3 | | RP9-RP10 | 4 | 6.00 | 4.96 | 0.00 | - | 5.69 |
| 4 | | RP9-RP10 | 6 | 7.00 | 6.56 | 0.32 | 0.08 | 7.13 |

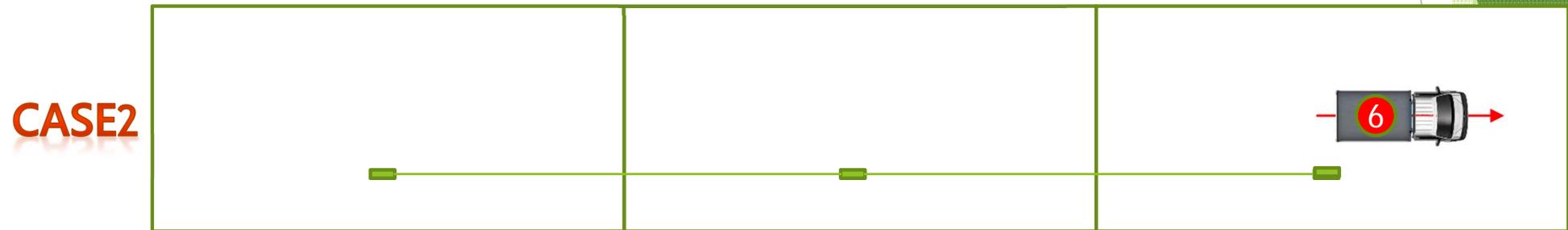
A1單元速度計配置



A1單元動態試驗車輛配置



時速 $V = 20$ KM/HR

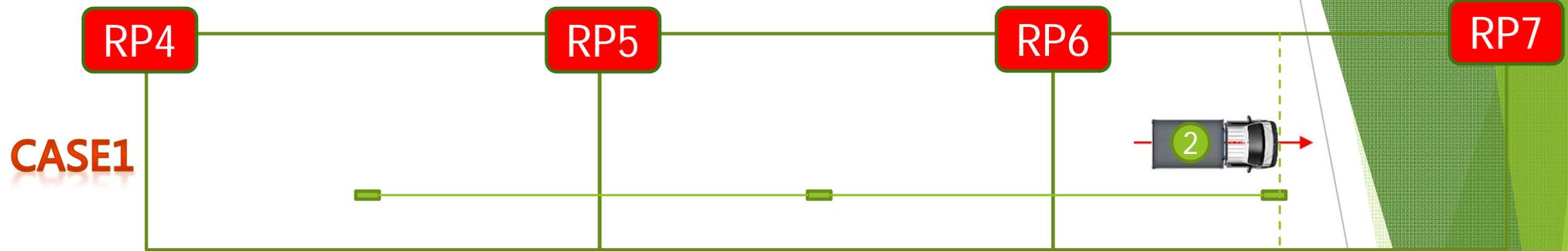


時速 $V = 40$ KM/HR

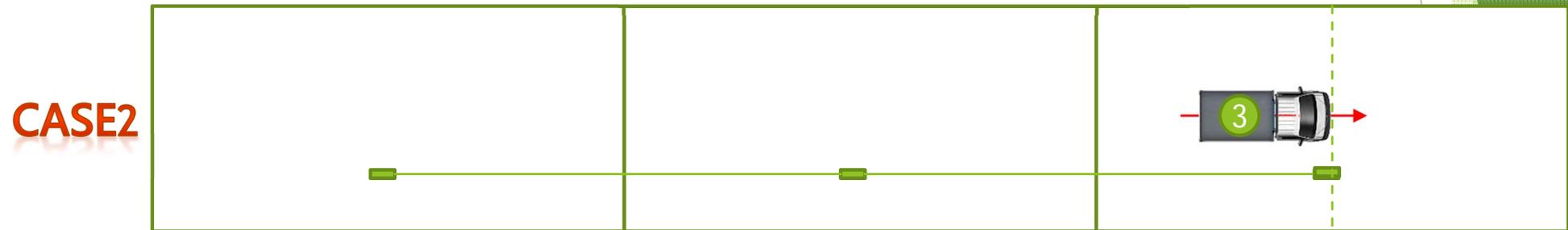


時速 $V = 60$ KM/HR

A1單元動態試驗車輛配置



時速 $V = 20$ KM/HR, 煞車



時速 $V = 40$ KM/HR, 煞車



時速 $V = 60$ KM/HR, 煞車

結論與建議

靜態載重部分

1. 逐步加載的過程可以發現變位與載重呈現性變化，顯示大梁仍在彈性範圍內。
2. 滿載重CASE在24hr後的殘留變位量測顯示，回彈率皆超過90%。

動態載重部分

1. 結構物自然頻率不隨車速變化，約在3.0Hz。
2. 第5跨(RP4~RP5)有較明顯的裂縫，受損較第10跨(RP9~RP10)嚴重，頻率顯示第5跨略低於第10跨，尚屬合理。

建議

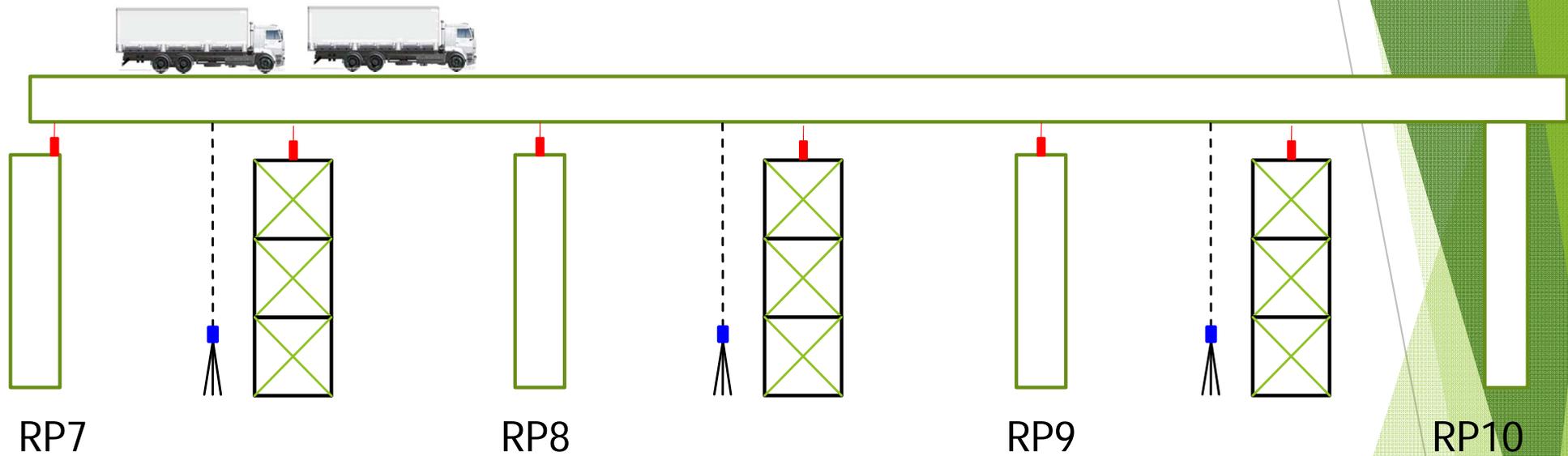
研判尚可符合使用效能，但仍建議另於通車後進行長期監測，確保橋梁使用安全。

報告完畢



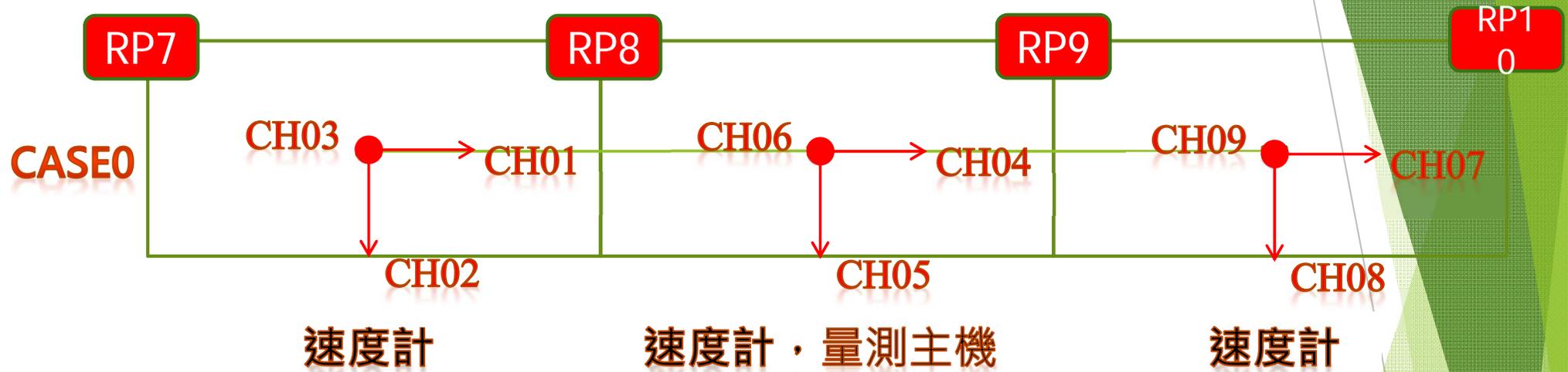


A2單元位移計配置

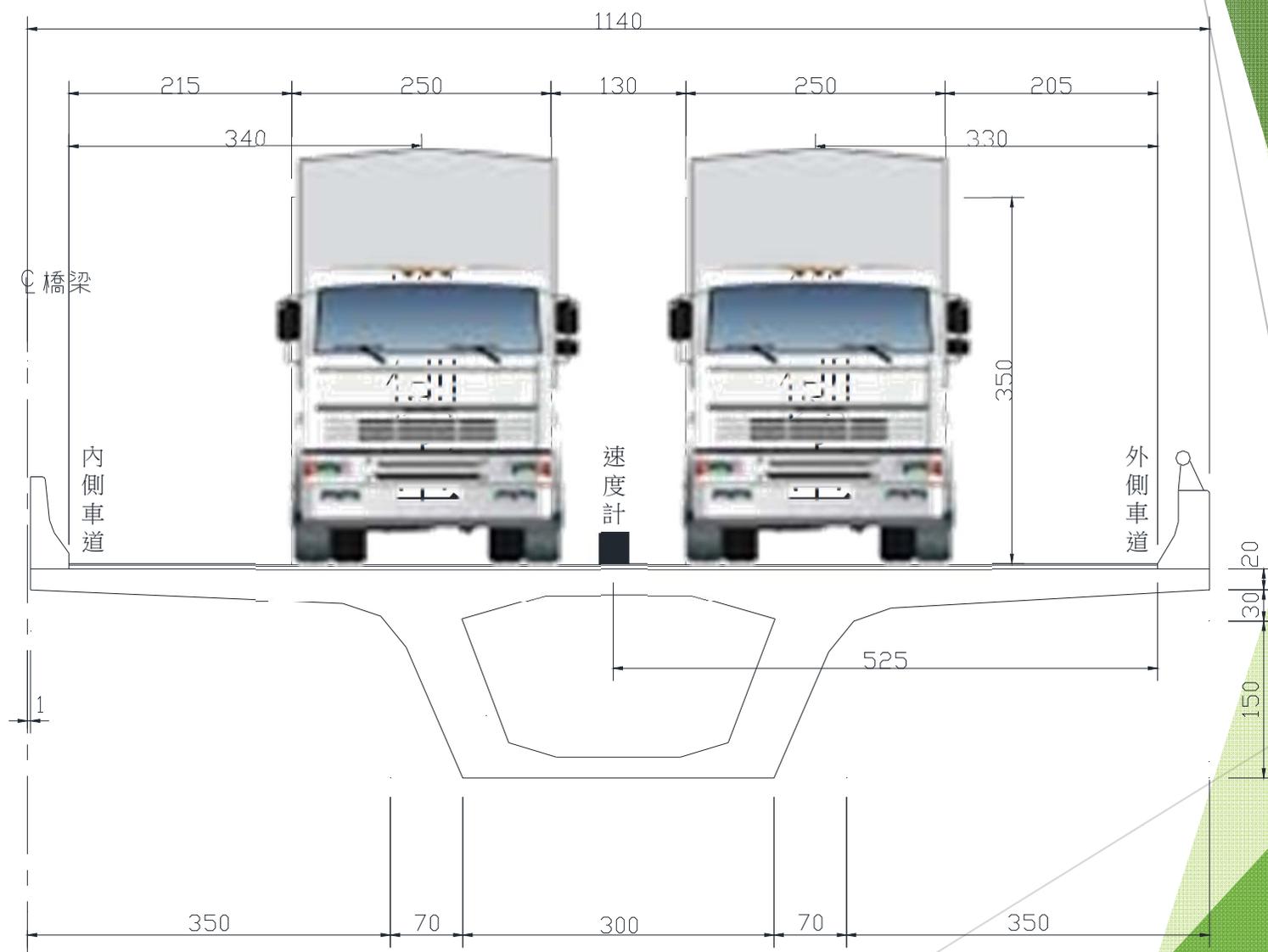


千分儀 X 6
雷射測距儀 X 3

A2單元感測器配置

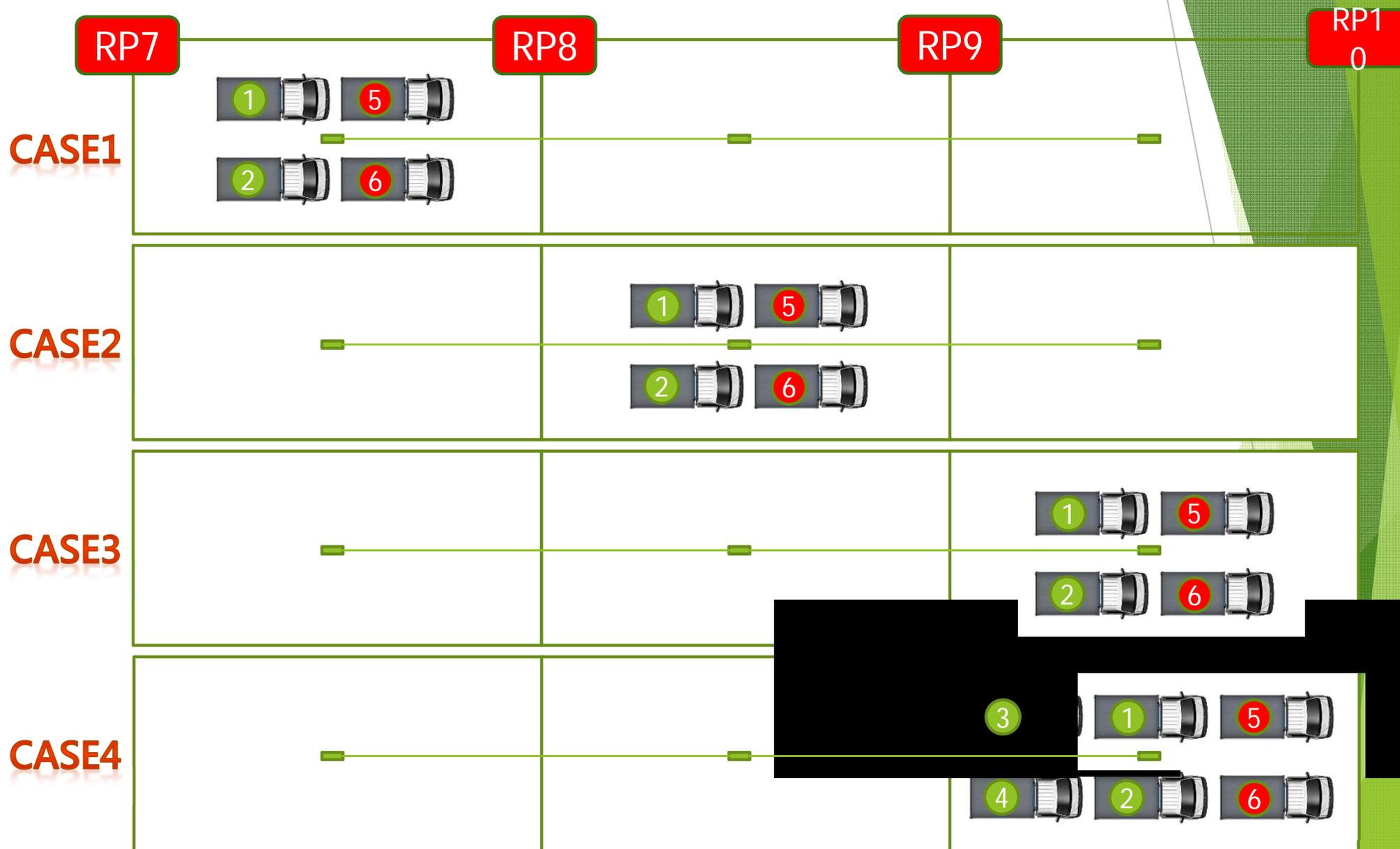


靜態試驗車輛配置剖面圖

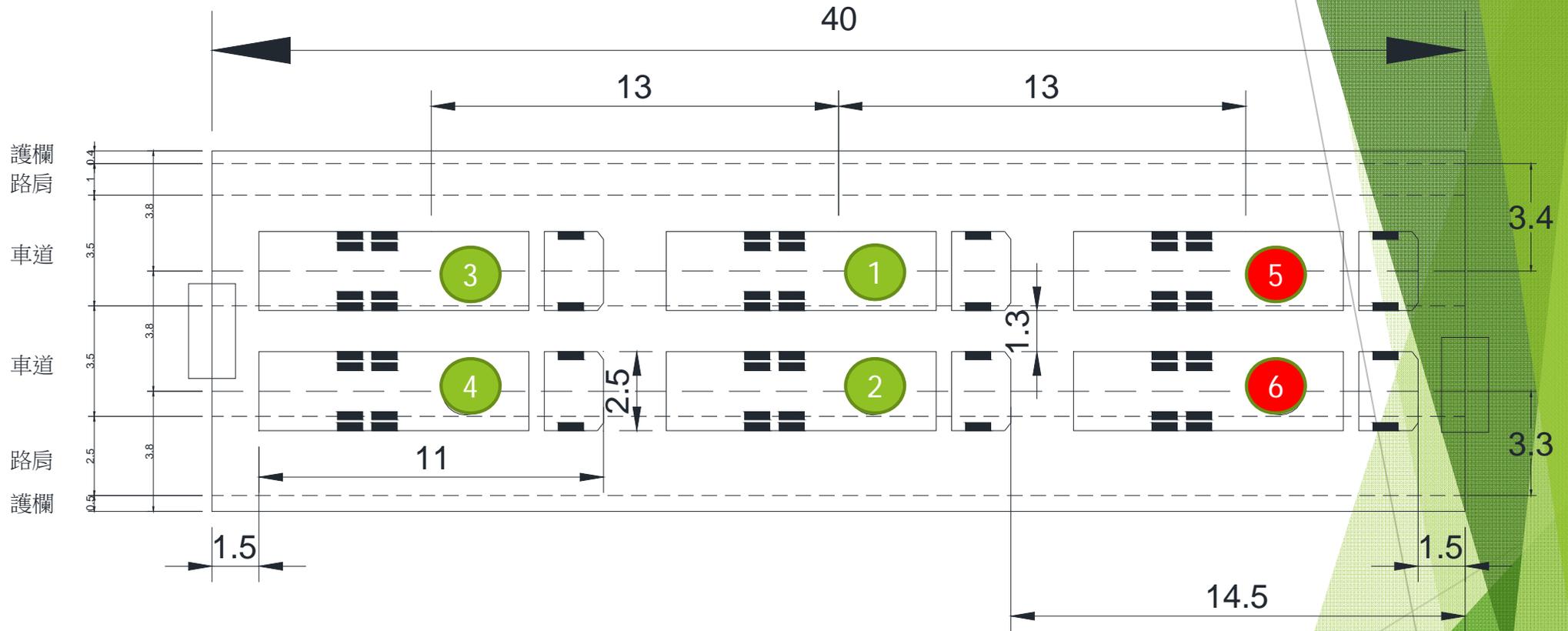


靜態載重試驗

A2單元靜態試驗車輛配置



A2單元CASE4車輛配置

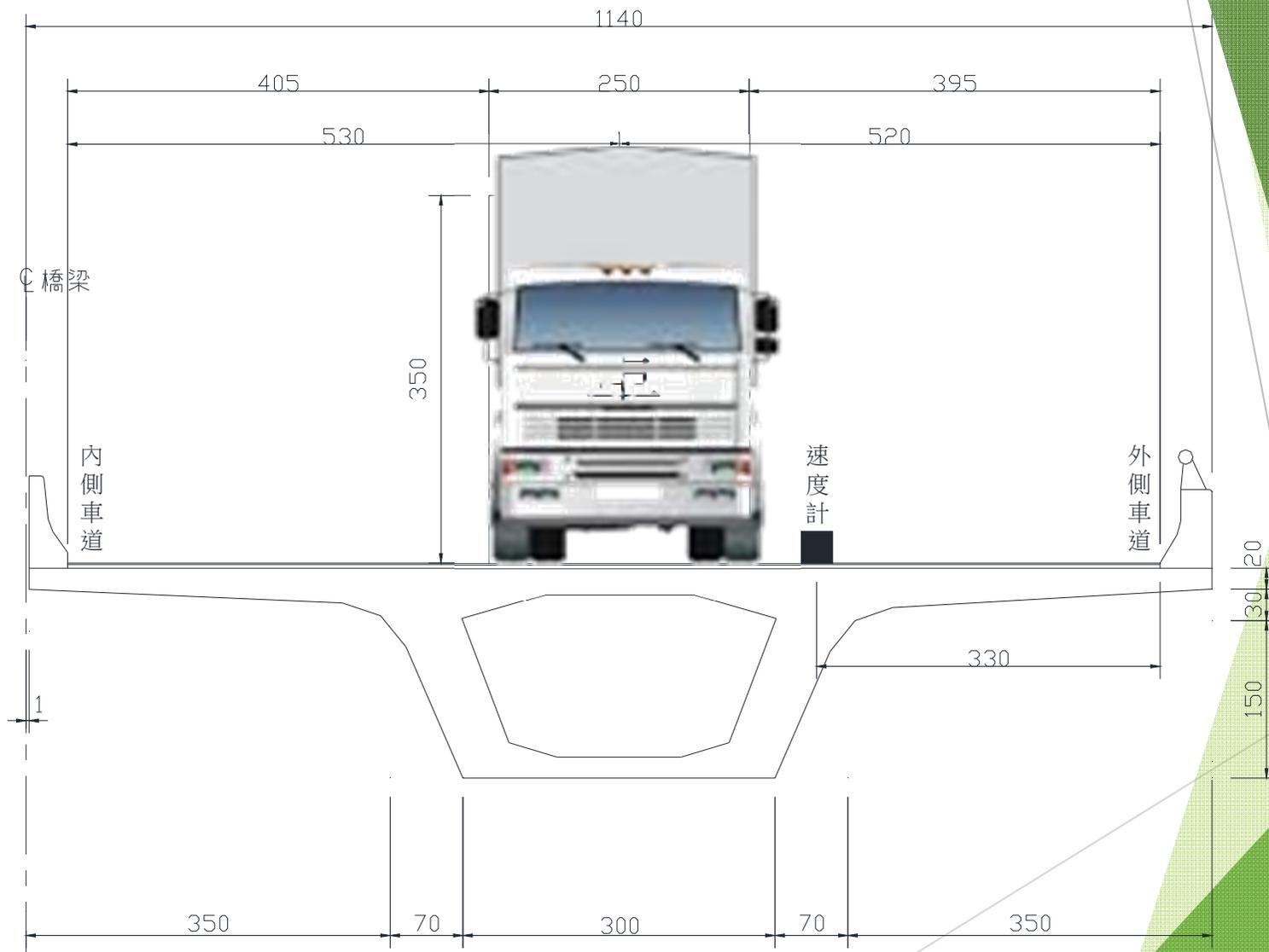


RP9

RP10

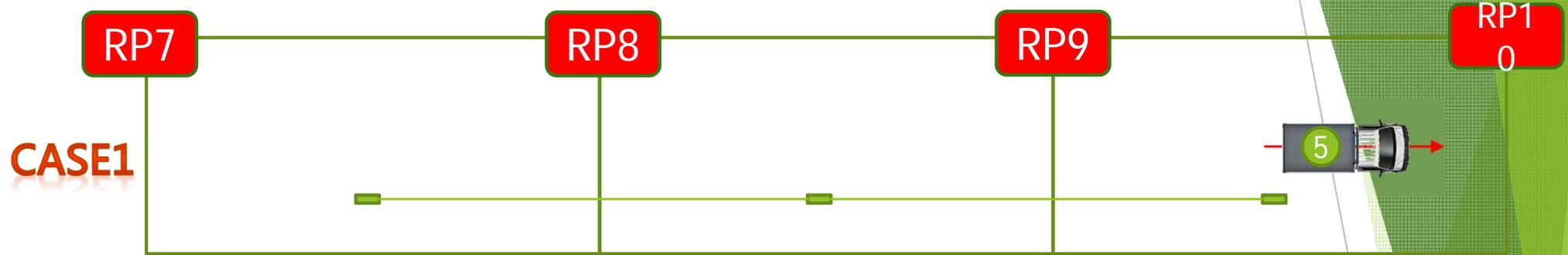
A2單元：CASE4

動態試驗車輛配置剖面圖

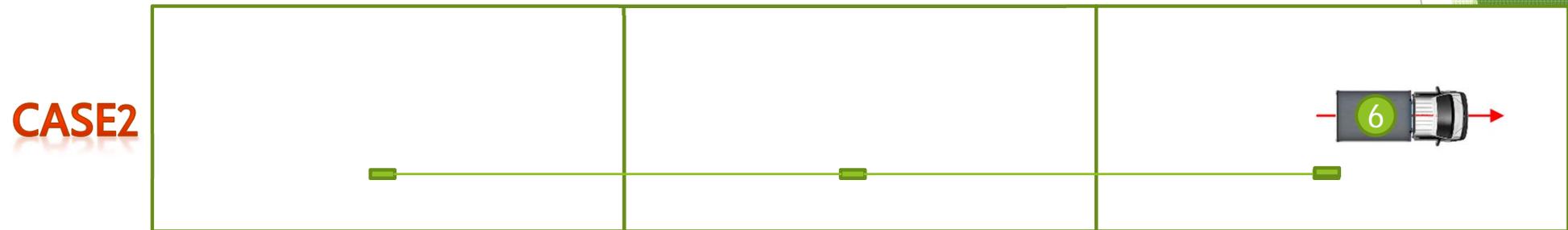


動態載重試驗

A2單元動態試驗車輛配置



時速 $V = 20$ KM/HR

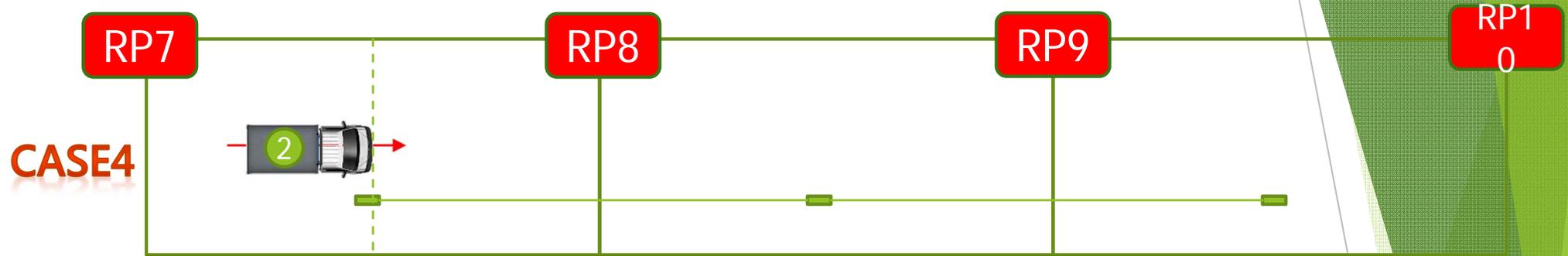


時速 $V = 40$ KM/HR

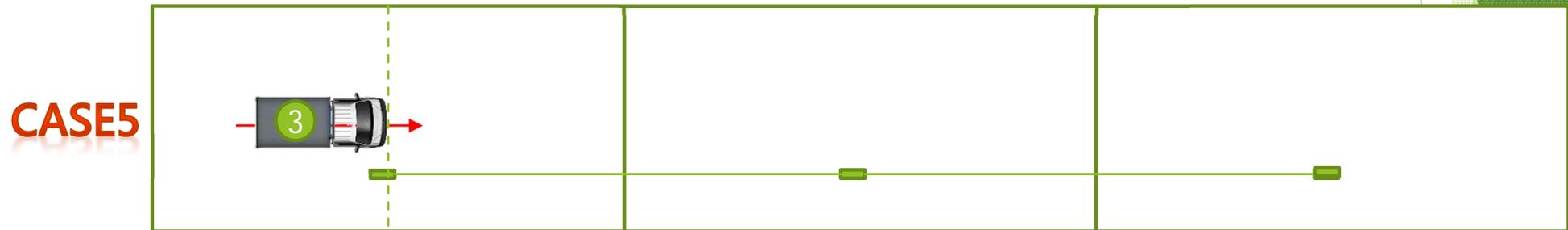


時速 $V = 60$ KM/HR

A2單元動態試驗車輛配置



時速 $V = 20$ KM/HR, 煞車



時速 $V = 40$ KM/HR, 煞車



時速 $V = 60$ KM/HR, 煞車

簡報結束
恭請指導