فصل چهارم- بار محوری (بخش اول)

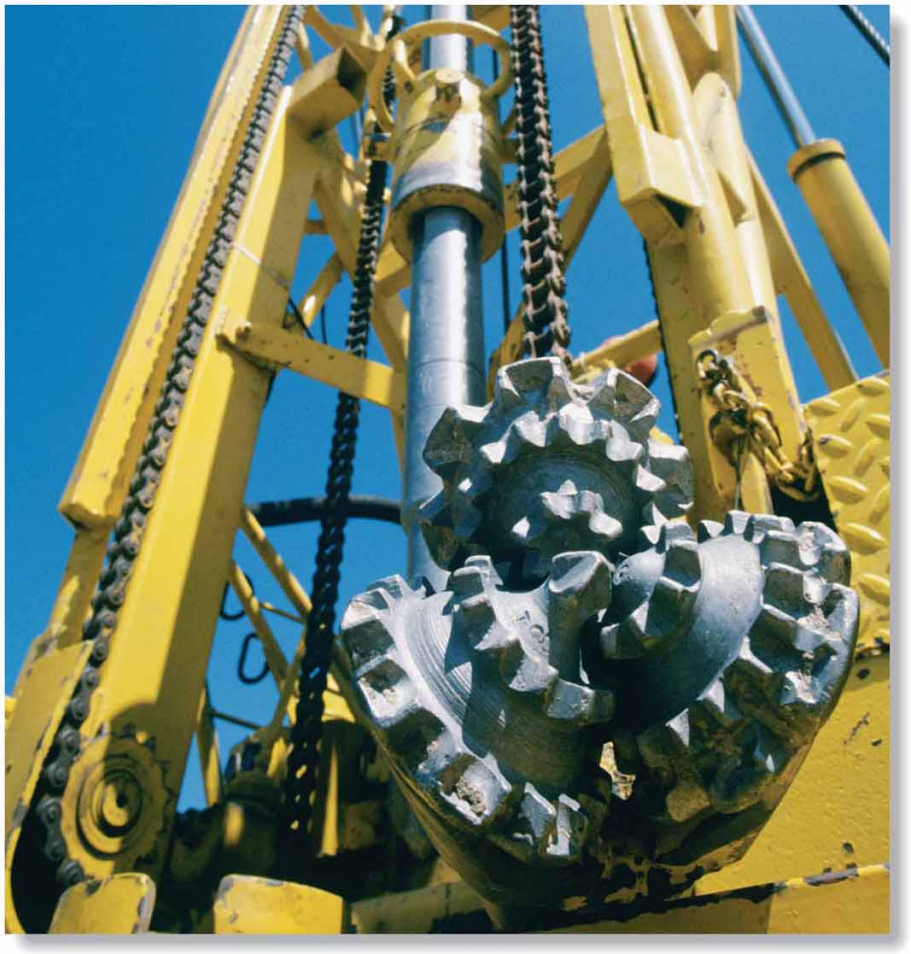

Figure: 04-01-COC
The string of drill pipe suspended from this traveling block on an oil rig is subjected to extremely large loadings and axial deformations.

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تنش

کرنش

تغییر شکل چیست؟

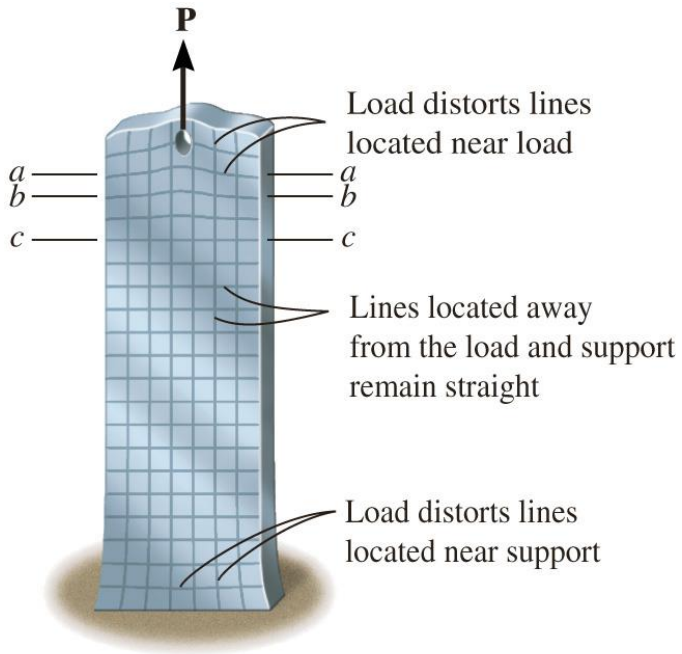
سایر مباحث:

تنش دمایی

نامعین استاتیکی

تمرکز تنش

۱-۴ اصل سنت ونت



(a)

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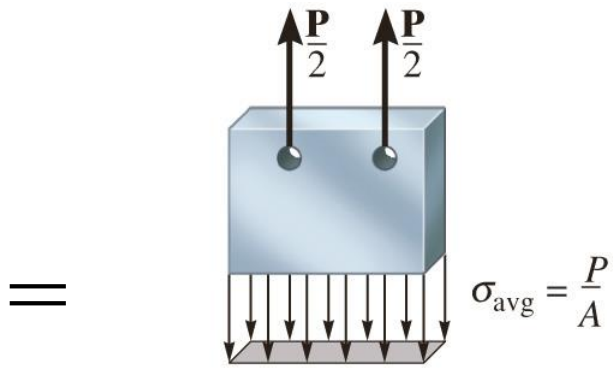

section *c–c*

(c)

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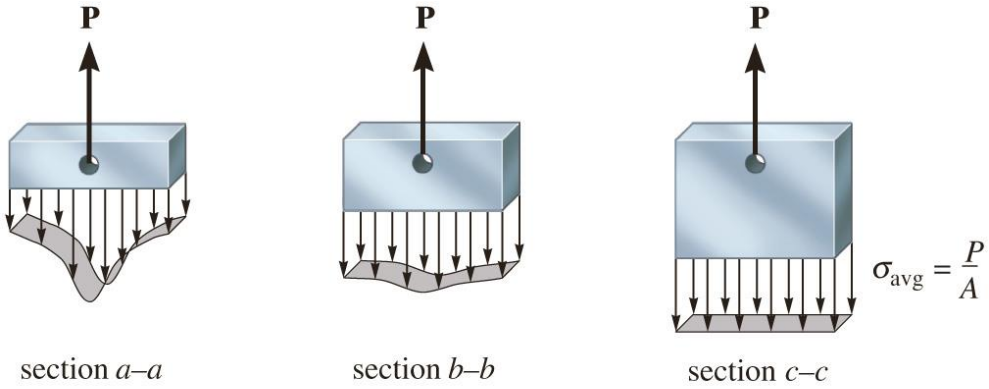
اصل St Venant's:

۱) پروفایل تنش فارق از اثرات محلی بارها به صورت یکنواخت خواهد بود (یعنی برابر P/A)

۲) تنش وکرنش تولید شده توسط سیستم بار معادل استاتیکی، مشابه خواهد بود.



section *a–a* section *b–b* section *c–c*

(b)

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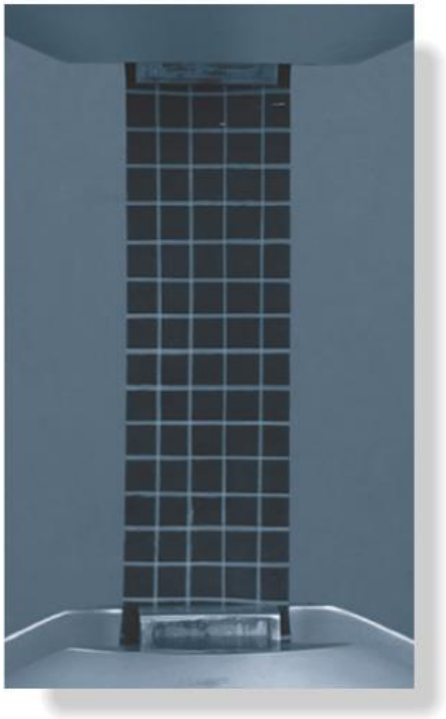
۴-۱ اصل سنت وننت



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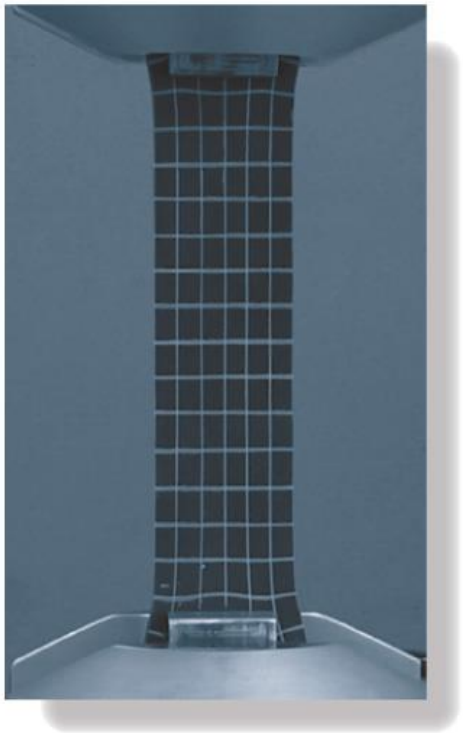

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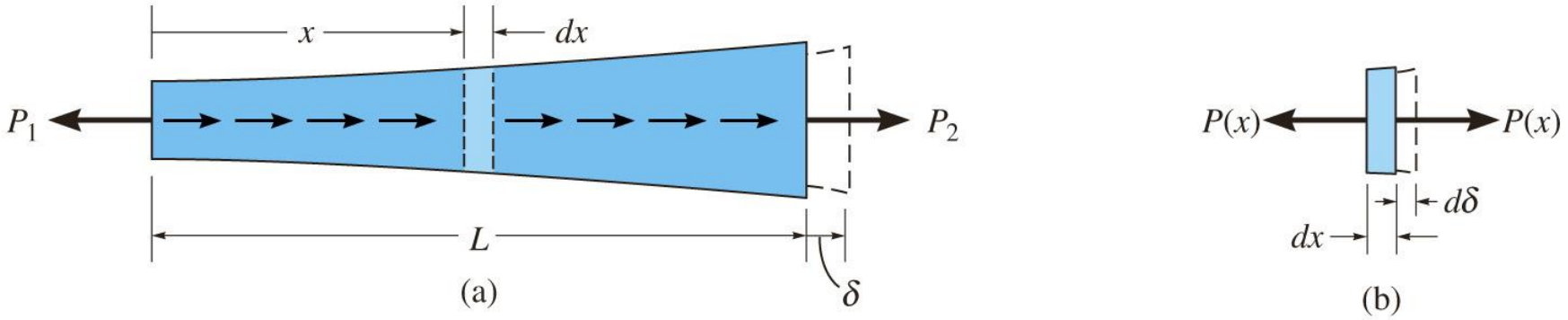
توجه کنید که تغییر شکل شبکه در وسط جسم یکنواخت است. بنابراین کرنش و تنش یکنواخت می باشد.

۴-۲: تغییر شکل الاستیک یک عضو محوری



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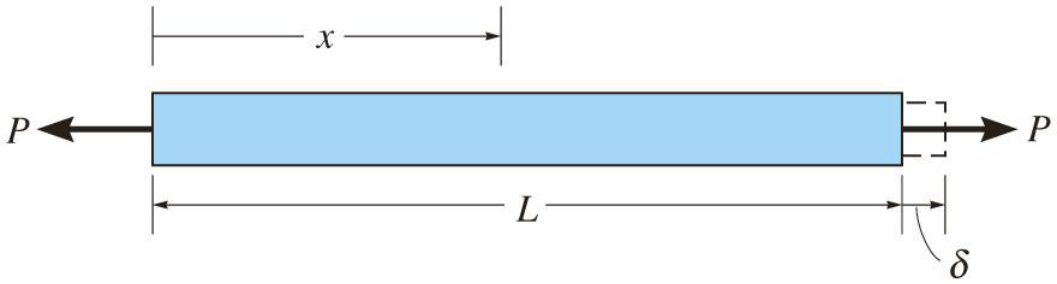
رابطه بین تغییر شکل δ و بار P را استخراج کنید.

بار و سطح مقطع ثابت



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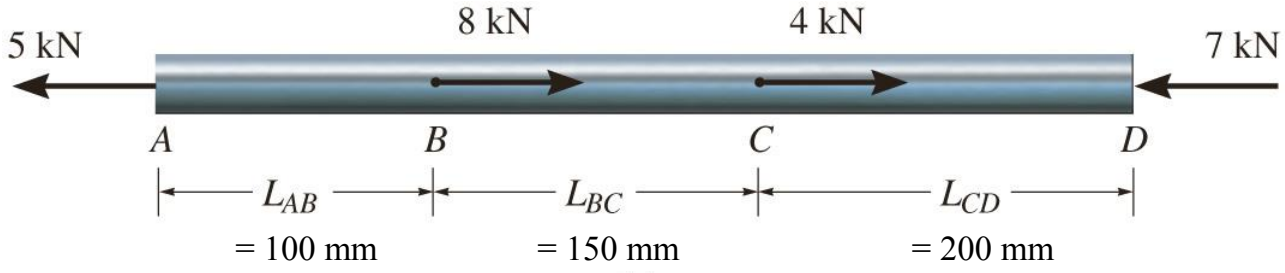
$$Deformation = \delta = \frac{PL}{AE}$$

برای مقاطع متعدد:

$$\delta_{total} = \sum \frac{PL}{AE}$$

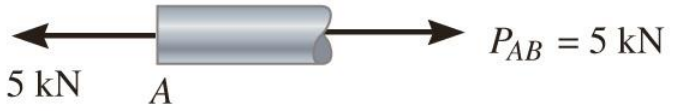
مثال: مقاطع متعدد. تغییر شکل کلی انتهای A را نسبت به D بیابید. سطح مقطع برابر $20\ mm^2$ و ماده از جنس فولاد با $E = 200\ GPa = 200\ x\ 10^9\ Pa$ است.

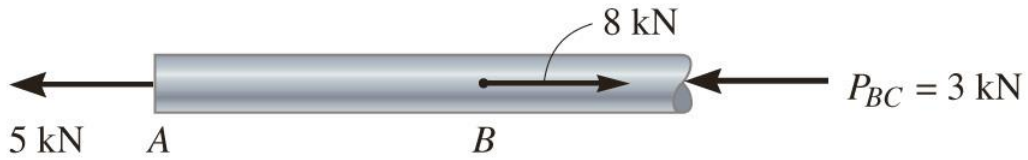


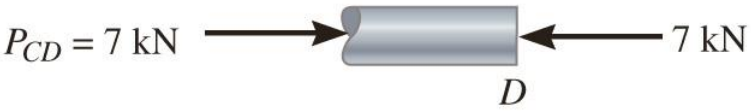
$$\delta_{A/D} = \sum \frac{PL}{AE}$$

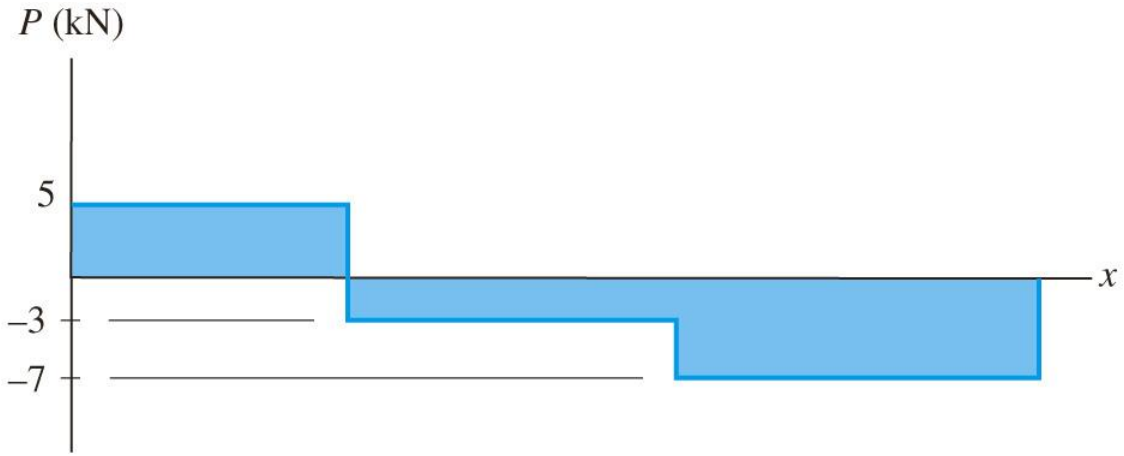
$$\delta_{A/D} = \frac{P_{AB}L_{AB}}{AE} + \frac{P_{BC}L_{BC}}{AE} + \frac{P_{CD}L_{CD}}{AE}$$

ابتدا بارهای داخلی را می یابیم









(c)

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$$\delta_{A/D} = \frac{P_{AB}L_{AB}}{AE} + \frac{P_{BC}L_{BC}}{AE} + \frac{P_{CD}L_{CD}}{AE}$$

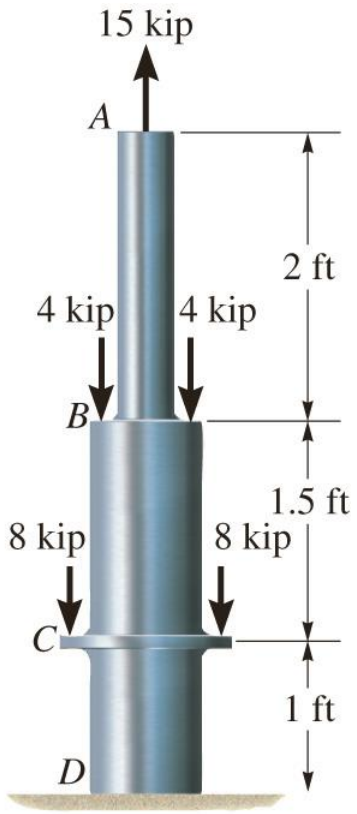
$$\delta_{A/D} = \frac{(5{,}000N)(.1m)}{AE} + \frac{(-3{,}000N)(.15m)}{AE} + \frac{(-7{,}000N)(.2m)}{AE}$$

$$\delta_{A/D} = \frac{-1{,}350}{AE} = \frac{-1{,}350}{(.00002)(200x10^{9})} = -3.38x10^{-4}m = -0.338mm$$

8اگر جنس ماده به جای فولاد از آلمونیوم بود، جواب آخر چه تغییری میکرد؟

مثال کتاب:

$\delta_{A/D}$ را بیابید



(a)

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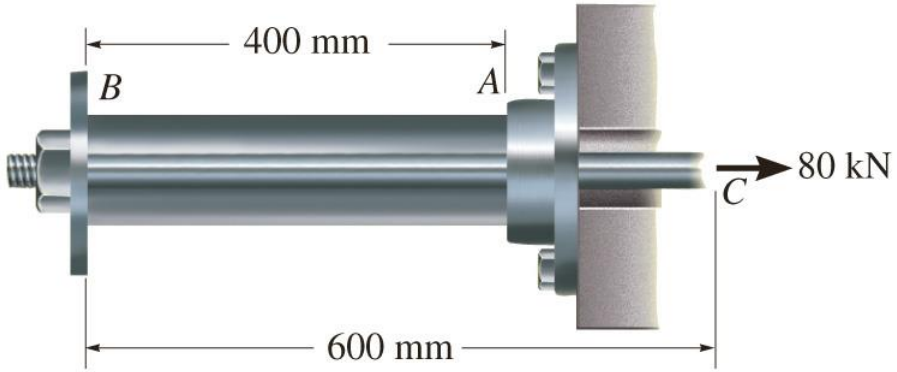
δ_C را تعیین کنید



(a)

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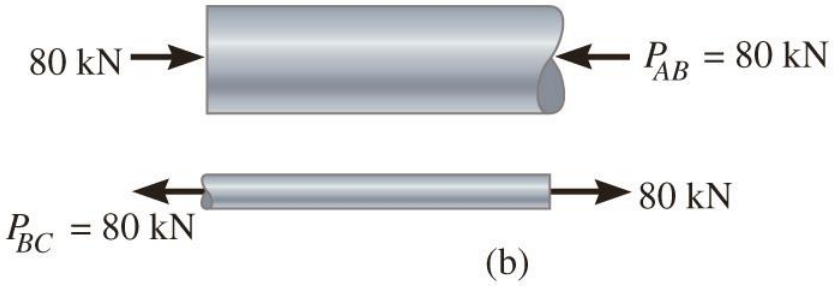

(b)

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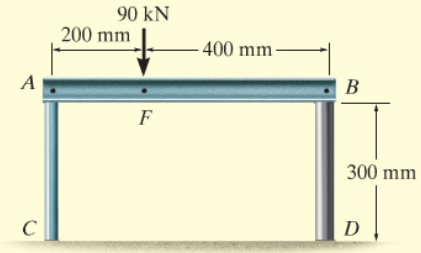
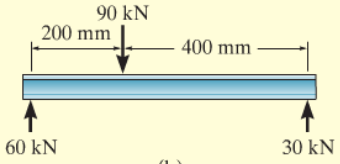
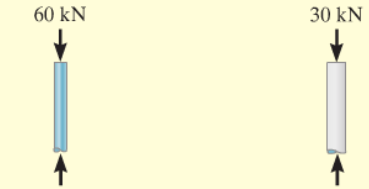
EXAMPLE 4.3



(a)



(b)



(c)

Rigid beam AB rests on the two short posts shown in Fig. 4–8*a*. AC is made of steel and has a diameter of 20 mm, and BD is made of aluminum and has a diameter of 40 mm. Determine the displacement of point F on AB if a vertical load of 90 kN is applied over this point. Take $E_{st} = 200$ GPa, $E_{al} = 70$ GPa.

SOLUTION

Internal Force. The compressive forces acting at the top of each post are determined from the equilibrium of member AB, Fig. 4–8*b*. These forces are equal to the internal forces in each post, Fig. 4–8*c*.

Displacement. The displacement of the top of each post is

Post *AC*:

$$\delta_A = \frac{P_{AC}L_{AC}}{A_{AC}E_{st}} = \frac{[-60(10^3)\text{ N}](0.300\text{ m})}{\pi(0.010\text{ m})^2[200(10^9)\text{ N/m}^2]} = -286(10^{-6})\text{ m}$$

$$= 0.286\text{ mm}\downarrow$$

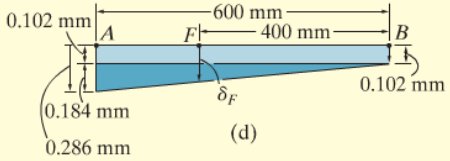
Post *BD*:

$$\delta_B = \frac{P_{BD}L_{BD}}{A_{BD}E_{al}} = \frac{[-30(10^3)\text{ N}](0.300\text{ m})}{\pi(0.020\text{ m})^2[70(10^9)\text{ N/m}^2]} = -102(10^{-6})\text{ m}$$

$$= 0.102\text{ mm}\downarrow$$

A diagram showing the centerline displacements at A, B, and F on the beam is shown in Fig. 4–8*d*. By proportion of the blue shaded triangle, the displacement of point F is therefore

$$\delta_F = 0.102\text{ mm} + (0.184\text{ mm})\left(\frac{400\text{ mm}}{600\text{ mm}}\right) = 0.225\text{ mm}\downarrow \quad \textit{Ans.}$$



(d)

Fig. 4–8